Liquid-crystal display devices

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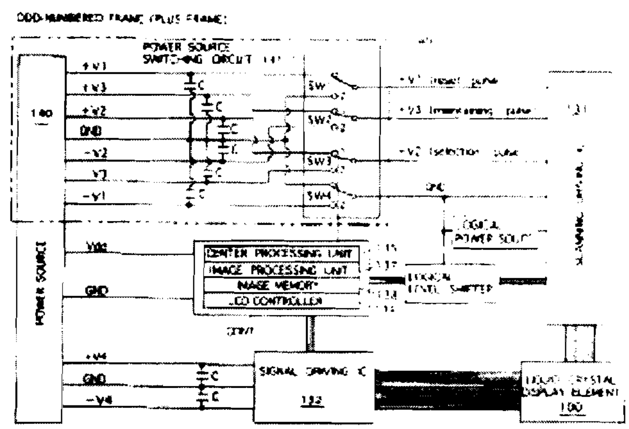
This invention is directed to a liquid crystal display apparatus which comprises a liquid crystal display element, and a driving device for driving the display element by simple matrix driving. The display element includes a liquid crystal layer exhibiting a cholesteric phase, and has scanning electrodes and signal electrodes. The driving device is configured such that a driving voltage of single polarity including a selection signal voltage is applied to the scanning electrodes in each frame, and the polarity of the driving voltage is reversed in every frame. The scanning electrodes are successively brought to a selected state by applying the selection signal voltage to each scanning electrode in a scanning period set for the scanning electrode, while a rewriting signal voltage corresponding to each scanning electrode in the selected state is applied to each signal electrode. An application period of the selection signal voltage to the scanning electrode is 1/2 the scanning period.



Liquid-crystal display devices

Description of corresponding document: **US2003156089**

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CROSS-REFERENCE TO RELATED APPLICATION
[0001] This application is based on Japanese patent application No.2002-87192 filed in Japan on Feb. 18, 2002, the entire content of which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION
[0002] 1. Field of the Invention
[0003] The present invention relates to a method of driving a liquid crystal display element, a device for driving a liquid crystal display element and a liquid crystal display apparatus.
[0004] 2. Description of Related Art
[0005] Usually the liquid crystal display apparatus includes a liquid crystal display element and a device for driving the liquid crystal display element.
[0006] The liquid crystal display element basically comprises a pair of substrates and a liquid crystal layer disposed between the substrates. By applying a predetermined driving voltage to the liquid crystal layer, the arrangement of liquid crystal molecules is controlled so that light incident on the liquid crystal element is modulated to perform a desired image display.
[0007] A wide variety of liquid crystal display elements have been proposed. In recent years, research has been conducted on a liquid crystal display element including a chiral nematic liquid crystal composition prepared by adding a chiral material to a nematic liquid crystal, the composition being caused to exhibit a cholesteric phase at room temperature due to the chiral material.
[0008] This type of liquid crystal display element is usable, for example, as a liquid crystal display element of reflection type utilizing a selective reflection capability of the chiral nematic liquid crystal composition.
[0009] In the reflection type liquid crystal display element, an image display can be performed by applying a high or low pulse voltage to switch the liquid crystal composition to a planar state (colored state) or to a focal conic state (transparent state).
[0010] Even after stopping the application of such pulse voltage, the liquid crystal composition can be kept in the planar state or the focal conic state, in other words, the liquid crystal composition can exhibit the so-called bi-stable property or can achieve a memory effect, whereby the image display can be kept after stopping the application of voltage.
[0011] The reflection type liquid crystal display element can perform a monochromatic (mono-color) image display utilizing a black or similar color background, a 2-color image display or a full color image display.
[0012] To realize, for example, an image display in full color, it is possible to use a laminate type liquid crystal display element including at least three liquid crystal layers, i.e. a red liquid crystal layer which can perform a red display, a green liquid crystal layer which can perform a green display, and a blue liquid crystal layer which can perform a blue display.
[0013] When at least one liquid crystal layer of this laminate type liquid crystal display element is maintained in a planar state (colored state), red, green, blue or other color can be displayed. When the laminate type liquid crystal display element is maintained in a focal conic state (transparent state), black color or like background color can be displayed.
[0014] In the liquid crystal display elements, usually electrodes are formed on the pair of substrates between which the liquid crystal layer is held, and are disposed so that the electrode-forming surfaces of the substrates are opposed to each other.
[0015] For example, a liquid crystal display element has an image display region composed of a plurality of pixels which are driven by a matrix driving system using a plurality of scanning electrodes and a plurality of signal electrodes which are opposed to each other.
[0016] In this liquid crystal display element, for example, a plurality of strips of scanning electrodes (or signal electrodes) extend in a predetermined direction with a specified gap in parallel with each other on one of the paired substrates, while a plurality of strips of signal electrodes (or scanning electrodes) extend in a predetermined direction with a specified gap in parallel with each other on the other substrate. The two groups of electrodes extend across each other when viewed from a plane. Each of the pixels corresponds to a portion of electrodes which intersect each other on the paired substrates.
[0017] Each electrode formed on the paired substrates is connected to a device for driving the liquid crystal display element. When a predetermined driving voltage is applied to the electrodes on the substrates from the driving device connected to the electrodes, the liquid crystal is driven to display a desired image.

[0018] The liquid crystal display element can be driven, for example, by a simple matrix driving method.
[0019] In the simple matrix driving method, the device for driving the liquid crystal display element includes, for example, a scanning driving IC connected to the plurality of scanning electrodes and capable of supplying a predetermined selection signal voltage to the scanning electrodes and a signal driving IC connected to the plurality of signal electrodes and capable of supplying a predetermined rewriting signal voltage to the signal electrodes.
[0020] The scanning electrodes are successively brought to a selected state by successively applying the predetermined selection signal voltage to each scanning electrode from the scanning driving IC connected to the plural scanning electrodes, while applying the predetermined rewriting signal voltage to each signal electrode in synchronization with application of the selection signal voltage to each scanning electrode from the signal driving IC connected to the plural signal electrodes to apply to the liquid crystal a voltage corresponding to a potential difference between the selection signal voltage and the rewriting signal voltage, whereby the liquid crystal is driven.
[0021] When the liquid crystal is driven by such simple matrix driving method, a voltage to be applied to the liquid crystal may be, for example, an alternating voltage which undergoes a periodical change in polarity of voltage waveform in each frame (for example, rectangular pulse voltage involving a periodical change in polarity of voltage waveform) from the viewpoint of increase in lifetime of the liquid crystal and others.
[0022] However, when an alternating voltage involving a periodical change in polarity of voltage waveform is applied to the liquid crystal which serves also as a condenser, a current more easily flows between the electrodes having the liquid crystal therebetween with an increase in the waveform repeating frequency of such alternating voltage, in which case the consumed power is increased for driving the liquid crystal display element.
[0023] Further, since a voltage corresponding to the alternating voltage is supplied to the scanning driving IC in one frame, the scanning driving IC is required to have a capability of withstanding a voltage corresponding to a difference between maximum and minimum voltages in the alternating electric field.
[0024] In the simple matrix driving method, a rewriting signal voltage is applied to the signal electrode corresponding to a pixel to be displayed in synchronization with the selection signal voltage in each scanning time in which the selection signal voltage is applied to the scanning electrode, and a voltage is applied based on the selection signal voltage and the rewriting signal voltage to the liquid crystal corresponding to the pixel to be displayed. In this operation, a voltage is applied to the liquid crystals corresponding to pixels not to be displayed by the rewriting signal voltage. Namely the so-called "cross-talk" occurs.
[0025] Due to the cross-talk in the the liquid crystal corresponding to those pixels, for example, one or more of the pixels to be displayed in high density are displayed in slightly low density, or one or more of the pixels to be displayed in low density are displayed in slightly high density. Namely an image like a shadow appears in the foregoing pixel portions. In other words, the phenomenon of shadowing occurs.

SUMMARY OF THE INVENTION

[0026] An object of the present invention is to provide a liquid crystal display apparatus which comprises a liquid crystal display element having a liquid crystal, and a driving device for driving the liquid crystal display element by matrix driving, the liquid crystal display apparatus being capable of reducing the consumption of power for driving the liquid crystal display element.
[0027] Another object of the present invention is to provide a liquid crystal display apparatus which comprises a liquid crystal display element having a liquid crystal, and a driving device for driving the liquid crystal display element by matrix driving, the liquid crystal display apparatus being capable of suppressing shadowing from occurring in image display when the liquid crystal suffers cross-talk due to a rewriting signal voltage applied to a signal electrode to display a better image.
[0028] A further object of the present invention is to provide a liquid crystal display apparatus which comprises a liquid crystal display element having a liquid crystal, and a driving device for driving the liquid crystal display element by matrix driving, the liquid crystal display apparatus being capable of employing a driving IC, which is low in voltage resistance, for driving the liquid crystal display element.
[0029] The present invention provides the following liquid crystal display apparatuses.
[0030] (1) First Liquid Crystal Display Apparatus
[0031] A liquid crystal display apparatus comprising:
[0032] a liquid crystal display element that includes a layer of a liquid crystal exhibiting a cholesteric phase, and a plurality of scanning electrodes and a plurality of signal electrodes extending across each other with the liquid crystal layer therebetween for performing display utilizing a selective reflection capability of the liquid crystal; and
[0033] a driving device for driving the liquid crystal display element by simple matrix driving,
[0034] wherein the driving device is configured such that (1) a driving voltage of single polarity including a selection signal voltage is applied to the scanning electrodes in each frame, and the polarity of the driving

voltage is reversed in every frame; (2) the scanning electrodes are successively brought to a selected state by applying the selection signal voltage to each scanning electrode in a scanning period set for the scanning electrode, while a rewriting signal voltage corresponding to each scanning electrode in the selected state is applied to each signal electrode in synchronization with application of the selection signal voltage to the scanning electrode; and (3) an application period of the selection signal voltage to the scanning electrode is [1/2] the scanning period (half of the scanning period).

[0035] (2) Second Liquid Crystal Display Apparatus

[0036] A liquid crystal display apparatus comprising:

[0037] a liquid crystal display element that includes a layer of a liquid crystal exhibiting a cholesteric phase, and a plurality of scanning electrodes and a plurality of signal electrodes extending across each other with the liquid crystal layer therebetween; and

[0038] a driving device for driving the liquid crystal display element by simple matrix driving,

[0039] wherein the driving device is configured such that (1) a driving voltage of single polarity including a selection signal voltage, a reset voltage and a maintaining voltage is applied to the scanning electrodes in each frame, and the polarity of the driving voltage is reversed in every frame; (2) the scanning electrodes are successively brought to a selected state by applying the selection signal voltage to each scanning electrode in a scanning period set for the scanning electrode, while a rewriting signal voltage corresponding to each scanning electrode in the selected state is applied to each signal electrode in synchronization with application of the selection signal voltage to the scanning electrode; (3) reset voltage is applied to the scanning electrode to bring the liquid crystal to a homeotropic state before applying the selection signal voltage, and the maintaining voltage is applied to the scanning electrode to establish a state of the liquid crystal to be selected by the selection signal voltage after applying the selection signal voltage; and (4) the rewriting signal voltage to be applied to the signal electrode is changed in polarity within the scanning period, and effective values of positive voltage and negative voltage of the rewriting signal voltage are substantially equal to each other within the scanning period.

[0040] (3) Third Liquid Crystal Display Apparatus

[0041] A liquid crystal display apparatus comprises a liquid crystal display element, and a driving device for driving the liquid crystal display element by simple matrix driving, wherein the liquid crystal display element includes a liquid crystal layer, and has a plurality of scanning electrodes and a plurality of signal electrodes extending across each other with the liquid crystal layer therebetween, wherein the driving device is configured such that a driving voltage of single polarity including a selection signal voltage is applied to the scanning electrodes in each frame, and the polarity of the driving voltage is reversed in every frame; the scanning electrodes are successively brought to a selected state by applying the selection signal voltage to each scanning electrode in a scanning period set for the scanning electrode, while a rewriting signal voltage corresponding to each scanning electrode in the selected state is applied to each signal electrode in synchronization with application of the selection signal voltage to the scanning electrode; and the rewriting signal voltage to be applied to the signal electrode is changed in polarity within the scanning period, and effective values of positive voltage and negative voltage of the rewriting signal voltage are substantially equal to each other within the scanning period.

[0042] The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0043] FIG. 1 is a sectional view schematically showing a structure of a reflective/laminate type full-color liquid crystal display element which can be driven by simple matrix driving method.

[0044] FIG. 2 is a block diagram showing an example of a driving circuit which is a main part of a driving device which applies driving voltages to the liquid crystal display layer.

[0045] FIG. 3 shows an example of a detailed structure of the driving circuit shown in FIG. 2.

[0046] FIG. 4 shows another example of a detailed structure of the driving circuit shown in FIG. 2, and shows a state of odd-numbered frame (plus frame) in which switching elements are changed over to a side 1.

[0047] FIG. 5 shows a state of even-numbered frame (minus frame) in the circuit shown in FIG. 4, in which the switching elements are changed over to a side 2.

[0048] FIG. 6(A) shows a basic driving waveform which is output from a scanning driving IC to each scanning electrode in the odd-numbered frames, and FIG. 6(B) shows a basic driving waveform which is output from the scanning driving IC to each scanning electrode in the even-numbered frames.

[0049] FIG. 7 shows waveforms of voltages which are output from the scanning driving IC to the scanning electrodes, a waveform of voltage which is output from a signal driving IC to one of signal electrodes, and waveforms of voltages which are applied to liquid crystals corresponding to pixels, in one of the odd-

numbered frames.
[0050] FIG. 8 shows waveforms of voltages which are output from the scanning driving IC to the scanning electrodes, a waveform of voltage which is output from the signal driving IC to one of the signal electrode, and waveforms of voltages which are applied to the liquid crystals corresponding to pixels, in one of the even-numbered frames.
[0051] FIG. 9 shows a waveform of selection pulse which is output to one of row electrodes (scanning electrodes), a waveform of signal pulse which is output to one of column electrodes (signal electrodes) and a waveform applied to the liquid crystal by these voltages for finally selecting the liquid crystal in a maximum selective reflection state, in one of the odd-numbered frames.
[0052] FIG. 10 shows a waveform of selection pulse which is output to one of the row electrodes, a waveform of signal pulse which is output to one of the column electrodes and a waveform which is applied to the liquid crystal by these voltages for finally selecting the liquid crystal in an intermediate tone display state, in one of the odd-numbered frames.
[0053] FIG. 11 shows a waveform of selection pulse which is output to one of the row electrodes, a waveform of signal pulse which is output to one of the column electrodes and a waveform which is applied to the liquid crystal by these voltages for finally selecting the liquid crystal in a transparent state, in one of the odd-numbered frames.
[0054] FIG. 12(A), FIG. 12(B), and FIG. 12(C) show enlarged portions, chiefly in selection periods, shown in FIG. 10, FIG. 9 and FIG. 11, of a waveform of selection pulse which is output to the row electrode, a waveform of signal pulse which is output to the column electrode, and a waveform applied to the liquid crystal by these voltages.
[0055] FIG. 13(A) to FIG. 13(C) show an example of signal pulse wherein continuous time T1 or T2 of positive or negative voltage is not the same as the selection signal application period Tsp.

DESCRIPTION OF THE PREFERRED EMBODIMENTS
[0056] The liquid crystal display apparatus according to a preferred embodiment of the present invention basically comprises a liquid crystal display element, and a driving device for driving the liquid crystal display element. The liquid crystal display element may include a layer of a liquid crystal exhibiting a cholesteric phase (cholesteric characteristics), and may perform display utilizing a selective reflection of the liquid crystal. The element has a plurality of scanning electrodes and a plurality of signal electrodes, these electrodes extending across each other with the liquid crystal layer therebetween. The driving device can drive the liquid crystal element by simple matrix driving.
[0057] The driving device is configured such that a driving voltage of single polarity including a selection signal voltage is applied to the scanning electrodes in each frame, and the polarity of the driving voltage is reversed in every frame.
[0058] The driving device is also configured such that the scanning electrodes are successively brought to a selected state by applying the selection signal voltage to each scanning electrode in a scanning period set for the scanning electrode, while a rewriting signal voltage corresponding to each scanning electrode in the selected state is applied to each signal electrode in synchronization with application of the selection signal voltage to the scanning electrode. An application period of the selection signal voltage to the scanning electrode may be [1/2] the scanning period (half of the scanning period). The scanning period is a period in which the selection signal voltage is applied to the scanning electrode.
[0059] In the liquid crystal display apparatus, the driving voltage to be applied to the scanning electrode for scanning in each frame for matrix driving of the liquid crystal display element is given a single polarity and the polarity is reversed in every frame so that the state of single polarity of voltage applied to the liquid crystal in each frame can continuously last for a prolonged period of time. Consequently it is possible to reduce a practical waveform repeating frequency of voltage to be applied to the liquid crystal as compared with use of alternating voltage which periodically changes in polarity of waveform of voltage in each frame.
[0060] Further it is possible to decrease a value of the driving voltage to be applied to the scanning electrode to [1/2], and an amount of power consumed for driving the liquid crystal display element can be correspondingly reduced. Namely the power consumption for driving the liquid crystal display element can be decreased. Moreover, a scanning driving IC which is inexpensive and is relatively low in voltage resistance can be used in view of reduction of the voltage to be supplied to the scanning driving IC to [1/2] compared with the use of alternating voltage.
[0061] Examples of the liquid crystal to be used for the liquid crystal display element which exhibit a cholesteric phase include those which exhibit a cholesteric phase (cholesteric characteristics) at room temperature (e.g. about 25[deg.] C.). The liquid crystals exhibiting a cholesteric phase include, for example, a cholesteric liquid crystal capable of showing a cholesteric phase by itself and a chiral nematic liquid crystal composition prepared by adding a chiral material to a nematic liquid crystal. The chiral nematic liquid crystal composition can selectively reflect light in a predetermined wavelength range and can achieve a

memory effect. The selective reflection wavelength can be advantageously adjusted by changing the amount of chiral material to be added.

[0062] The driving device for driving the liquid crystal display element may comprise a scanning driving IC to be connected to the plurality of scanning electrodes, a signal driving IC to be connected to the plurality of signal electrodes, and a controller for controlling these driving ICs. The controller may be adapted to control the scanning driving IC such that a selection signal voltage is successively applied to the scanning electrodes to bring the electrodes to a selective state, while it may be adapted to control the signal driving IC such that a rewriting signal voltage is applied to each signal electrode, more specifically a rewriting signal voltage corresponding to the scanning electrode in the selective state is applied to the signal electrode in synchronization with application of the selection signal voltage to each scanning electrode.

[0063] The controller may control the scanning driving IC in a manner such that the driving voltage to be applied to the scanning electrode in scanning in each frame for matrix driving of the liquid crystal display element is given a single polarity in each frame and inversion of the polarity is performed in every frame.

[0064] In order to properly drive the liquid crystal exhibiting a cholesteric phase in each pixel, a predetermined reset voltage may be applied to the scanning electrode for a specified time period (reset period) to bring the liquid crystal to a homeotropic state before a predetermined period (selection period) of applying the selection signal voltage. In this case, the selection signal voltage is a sufficient voltage to change the homeotropic liquid crystal to a desired state.

[0065] A predetermined maintaining voltage for establishing a state of the liquid crystal to be selected by the selection signal voltage may be applied to each scanning electrode for a specified period (maintaining period) after applying the selection signal voltage.

[0066] In the selection period for applying the selection signal voltage, the driving voltage for the scanning electrode may be 0V for a specified period (pre-selection period) after the reset period for applying the reset voltage and before applying the selection signal voltage, and the driving voltage for the scanning electrode may be 0V for a specified period (post-selection period) before the maintaining period for applying the maintaining voltage and after applying the selection signal voltage.

[0067] When each scanning electrode is brought to a selective state by successively applying the selection signal voltage to the plurality of scanning electrodes while applying the rewriting signal voltage corresponding to the scanning electrode in the selective state in synchronization with application of the selection signal voltage to the scanning electrode, the rewriting signal voltage may be such that the rewriting signal voltage is changed in polarity within the scanning period and effective values of positive and negative voltages of the rewriting signal voltage is substantially equal to each other within the scanning period.

[0068] With these features, when the liquid crystals corresponding to the pixels are subjected to a cross-talk due to the rewriting signal voltage applied to the signal electrode, voltages applied to the liquid crystals due to the cross-talk can be rendered substantially uniform.

[0069] However, in this case, if the application period of the selection signal voltage is as long as the scanning period, the pixel to be displayed is not be properly displayed by the rewriting signal voltage which is changed in its polarity in the scanning period.

[0070] In view of the above, it is recommendable that the application period of the selection signal voltage to be applied to the scanning electrodes is [1/2] the scanning period when applying the driving voltages to the plurality of scanning electrodes and the plurality of signal electrodes for matrix driving.

[0071] The pixels to be displayed can be properly displayed, if the following features are realized: an application period of the selection signal voltage is [1/2] the scanning period; the rewriting signal voltage is changed in its polarity within the scanning period; the effective values of positive and negative voltages of the rewriting signal voltage are substantially equal to each other within the scanning period; each of total of period(s) of the positive voltage and total of period(s) of the negative voltage is as long as the application period of the selection signal voltage.

[0072] The following also results from such features. When liquid crystals corresponding to pixels are subjected to the cross-talk due to the rewriting signal voltage applied to the signal electrode, the voltages applied to the liquid crystals corresponding to pixels due to the cross-talk can be rendered substantially uniform. Thereby it is possible to suppress a shadowing in image display from occurring in the liquid crystals subjected to the cross-talk, resulting in better image display. Furthermore, each pixel can be displayed in a planar state (selective reflective state), in a focal conic state (transparent state) or in an intermediate tone state (mixed states), for example, by shifting the phase of the rewriting signal voltage.

[0073] In the liquid crystal display apparatus and the device for driving the liquid crystal display element which have the scanning driving IC, the signal driving IC and the controller, the controller may be adapted to control the signal driving IC so as to adjust the application period of the selection signal voltage to [1/2] the scanning period, and may be adapted to control the signal driving IC so as to change the polarity of the rewriting signal voltage within the scanning period, so as to substantially equalize the effective values of positive and negative voltages with each other in the scanning period, and so as to allow the rewriting

signal voltage to equalize each of total of period(s) of the positive voltage and total of period(s) of the negative voltage with the application period of the selection signal voltage within the scanning period.
[0074] At any rate, it is desired to equalize an application period of the rewriting signal voltage with the scanning period as far as the rewriting signal voltage is concerned in which the polarity thereof is changed within the scanning period, the effective values of positive and negative voltages are substantially equal to each other in the scanning period, and each of total of period(s) of the positive voltage and total of period(s) of the negative voltage is made equal to the application period of the selection signal voltage within the scanning period.
[0075] A rectangular pulse voltage which has a duty ratio of 50% in the scanning period and in which the absolute values of positive and negative voltages are identical with each other can be mentioned as a typical example of the rewriting signal voltage in which the polarity is changed in the scanning period, the effective values of positive and negative voltages are substantially equal to each other in the scanning period, each of the total of period(s) of the positive voltage and the total of period(s) of the negative voltage is equal to the application period of the selection signal voltage and the application period of the rewriting signal voltage is as long as the scanning period.
[0076] When the selection signal voltage is such that its application period is [1/2] the scanning period, and the rewriting signal voltage is, for example, a rectangular pulse voltage which has a duty ratio of 50% within the scanning period and in which the absolute values of positive and negative voltages are identical with each other, voltages to be applied to the liquid crystals corresponding to pixels due to the cross-talk can be made substantially constant, whereby the shadowing occurring due to the cross-talk in image display can be further suppressed. This matter will be described in greater detail later.
[0077] At any rate, the phase of the signal voltage may be adjusted to bring about the following: the application period of the selection signal voltage is [1/2] the scanning period; the rewriting signal voltage changes its polarity within the scanning period; the effective values of positive and negative voltages of the rewriting signal voltage are substantially equal to each other within the scanning period; and the rewriting signal voltage is such that each of the total of period(s) of the positive voltage and the total of period(s) of the negative voltage is as long as the application period of the selection signal voltage within the scanning period.
[0078] The voltage to be applied to the liquid crystal exhibiting a cholesteric phase can be changed by adjusting the phase of the signal voltage so that the liquid crystal can be brought to a planar state (selective reflective state), to a focal conic state (transparent state) or to a mixed state (a planar state and a focal conic state are mixed). Thereby the liquid crystal element is allowed to perform a selective reflective (colored) display, a transparent display or an intermediate tone display.
[0079] At any rate, the driving voltage may be applied to the scanning electrode by the scanning driving IC connected to a power source which can switch positive and negative of output voltage, and can switch the positive and negative of power source output voltage in every frame. Thereby, the driving voltage to be applied to the scanning electrode can be given a single polarity in each frame and the polarity can be reversed in every frame. In this way, a driving of the liquid crystal element can be realized by simple circuit structure.
[0080] The liquid crystal apparatus and the device for driving the liquid crystal display element, which have the scanning driving IC, the signal driving IC and the controller, may be provided with a power source which is connected to the scanning driving IC and which can switch positive and negative of output voltage, and the driving voltage may be applied to the scanning electrodes by the scanning driving IC connected to the power source.
[0081] In this case, the controller may control the power source and the scanning driving IC such that the power output voltage is switched from positive to negative or negative to positive in every frame, whereby the driving voltage to be applied to the scanning electrode is given a single polarity in each frame and the polarity is reversed in every frame.
[0082] The liquid crystal display element may be driven as follows. The plurality of scanning electrodes may be scanned at an interval of one electrode or plural electrodes, and remaining electrodes may be scanned in the same manner. When scanning is conducted at an interval of plural electrodes, the cycle is successively repeated, namely an interlace driving may be performed.
[0083] The plural scanning electrodes may be selectively and successively scanned in each frame, namely a progressive (non-interlace) driving may be conducted. In the case of interlace driving in which one frame is separated into plural fields, the polarity of selection signal voltage to be applied to the scanning electrode in each field may be reversed in every field.
[0084] Embodiments of the liquid crystal display apparatus will be described with reference to the accompanying drawings.
[0085] (Liquid Crystal Display Element, see FIG. 1)
[0086] First, a liquid crystal display element which includes a liquid crystal exhibiting a cholesteric phase (cholesteric characteristics) will be described.

[0087] FIG. 1 is a sectional view schematically showing a structure of a reflective/laminate type full-color liquid crystal display element which can be driven by simple matrix driving method.
[0088] The liquid crystal display element 100 shown in FIG. 1 comprises a light absorbing layer 121, a red display layer 111R lying on the layer 121 and capable of performing display by switching a red selective reflective state to a transparent state and vice versa; a green display layer 111G lying on the layer 111R and capable of performing display by switching a green selective reflective state to a transparent state and vice versa; and a blue display layer 111B lying on the layer 111G and capable of performing display by switching a blue selective reflective state to a transparent state and vice versa.
[0089] Each of the display layers 111R, 111G, 111B includes resin column structures 115, a liquid crystal 116 and spacers 117 between a pair of transparent substrates 112 having transparent electrodes 113, 114. Insulating films 118 and orientation-controlling films 119 are formed on the transparent electrodes 113, 114 when so required.
[0090] A seal material 120 is provided to seal the liquid crystal 116 at a periphery of the space between the substrates 112 (outside the display region).
[0091] The transparent electrodes 113, 114 are connected to a scanning driving IC 131 and a signal driving IC 132 (see FIG. 2), respectively, and a predetermined pulse voltage is applied to the transparent electrodes 113, 114, respectively. In response to the applied voltage, the display of the liquid crystal 116 is switched between a transparent state which passes visible light therethrough and a selective reflective state which selectively reflects visible light of specific wavelengths.
[0092] The transparent electrodes 113 formed in the display layers 111R, 111G, 111B, respectively are a plurality of strip electrodes extending in parallel with each other with a minute space away from each other. The transparent electrodes 114 formed in the display layers 111R, 111G, 111B, respectively are also a plurality of strip electrodes extending in parallel with each other with a minute space away from each other.
[0093] The transparent electrodes 113, 114 are opposed to each other in a direction orthogonal to each other when viewed on a plane. Voltages are successively applied to the upper and lower strip electrodes. Namely a voltage is successively applied to the liquid crystal 116 in a matrix manner to display an image. This method is called matrix driving. Each pixel corresponds to a portion at which the electrode 113 and the electrode 114 cross each other. Such matrix driving is conducted on each display layer, whereby a full color image can be displayed in the liquid crystal display element 100.
[0094] Generally speaking, in a liquid crystal display element with a liquid crystal exhibiting a cholesteric phase between two substrates, the liquid crystal is switched between a planar state and a focal conic state to display an image. When the liquid crystal is in the planar state, a light of wavelength [lambda]=P.n (wherein P is a helical pitch of the cholesteric liquid crystal and n is an average refractive index of the liquid crystal) is selectively reflected. When the liquid crystal is in the focal conic state, light incident on the liquid crystal is scattered in the case of selective reflective wavelength of the cholesteric liquid crystal being in a range of infrared light. When the selective reflective wavelength of the cholesteric liquid crystal is shorter, light is less scattered and visible light substantially passes through the liquid crystal.
[0095] Consequently, when a selective reflective wavelength is set in a visible light range and a light absorbing layer is formed on a side opposite to the observation side of the element, a selective relective color is displayed in the planar state while a black display can be done in the focal conic state.
[0096] When a selective reflective wavelength is set at an infrared light range and a light absorbing layer is formed on a side opposed to the observation side of the element, whereby light of wavelength in the infrared light range is reflected while light of wavelength in visible light range passes therethrough in the planar state, so that a black color can be displayed. A white color can be displayed due to light scattering in the focal conic state.
[0097] In the liquid crystal display element 100 having the display layers 111R, 111G, 111B superposed on each other, when the blue display layer 111B and the green display layer 111G are brought to a transparent state wherein liquid crystal molecules are in a focal conic arrangement, and the red display layer 111R is brought to a selective reflective state wherein liquid crystal molecules are in a planar arrangement, a red display can be performed. The blue display layer 111B is brought to a transparent state wherein liquid crystal molecules are in a focal conic arrangement, and the green display layer 111G and the red display layer 111R are brought to a selective reflective state wherein liquid crystal molecules are in a planar arrangement, whereby a yellow display can be performed. Similarly the transparent state or selective reflective state is suitably selected as the state of each display layer, whereby red, green, blue, white, cyan, magenta, yellow or black color can be displayed.
[0098] Moreover, when an intermediate selective reflective state is selected as the state of display layers 111R, 111G, 111B, an intermediate color can be displayed and can be utilized for full color display.
[0099] A liquid crystal exhibiting a cholesteric phase (cholesteric characteristics) at room temperature can be preferably used as the liquid crystal 116. Especially it is suitable to use a chiral nematic liquid crystal prepared by adding a chiral material to a nematic liquid crystal in an amount sufficient to show a cholesteric phase.

[0100] The chiral material is an additive which is capable of twisting the molecules of nematic liquid crystal when added to the nematic liquid crystal. The nematic liquid crystal is imparted a helical structure of twisted molecules of liquid crystal by addition of the chiral material to the nematic liquid crystal, whereby it is caused to show a cholesteric phase.
[0101] The structure of liquid crystal display layer is not necessarily limited to the above. A resin structure in the form of a wall or the like may be used instead of the column structure 115, or such resin structure may be omitted. Useful structures of the liquid crystal layer include conventional structures such as a layer structure wherein a liquid crystal is dispersed in a three-dimensional polymer network, a layer structure wherein a three-dimensional polymer network is formed in a liquid crystal (so-called polymer-dispersed type liquid crystal composite film) and the like.
[0102] (Driving Circuit, see FIGS. 2 and 3)
[0103] FIG. 2 is a block diagram showing an example of a driving circuit which is a main part of a driving device for applying driving voltages to the liquid crystal display layer. FIG. 3 shows an example of a detailed structure of the driving circuit shown in FIG. 2. A logical power source and a logical level shifter shown in FIG. 3 are omitted in FIG. 2.
[0104] The liquid crystal display apparatus comprises the liquid crystal display element 100 and the driving device shown in FIGS. 2 and 3.
[0105] According to the illustrated liquid crystal display apparatus, driving ICs 131, 132 are controlled by an LCD controller 136 based on image data stored in an image memory 138 included in a controller CONT to be described later. Voltages are successively applied between scanning electrodes and signal electrodes in the liquid crystal display element 100, whereby an image is written in the liquid crystal display element 100.
[0106] FIGS. 2 and 3 and FIGS. 4 and 5 to be described later show the driving ICs 131, 132 provided in any of the red, green and blue display layers. More specifically, the driving ICs 131, 132 are actually provided in each of the red, green and blue display layers. The driving ICs 131, 132 are preferably provided in each of the red, green and blue display layers (namely ICs are provided in three kinds of layers, respectively). It is possible to use any one of driving ICs 131, 132 in common with these layers.
[0107] The driving device shown in FIGS. 2 and 3 include the scanning driving IC (driver) 131, the signal driving IC (driver) 132, the controller CONT and a power source 140.
[0108] The controller CONT is provided with a central processing unit (CPU) 135 adapted to control the driving device in its entirety, the LCD controller 136 adapted to control the driving ICs, an image processing unit 137 for processing image data in various manners, and the image memory 138 for storing image data. A power is supplied to the controller CONT from a power source 140. The controller CONT is connected to the signal driving IC 132 and, via a logical level shifter, to the scanning driving IC 131. The logical level shifter is a circuit adapted to shift a ground(GND) potential to 0V for compensation if the ground(GND) potential is changed from 0V despite the ground (GND) to be kept at 0V corresponding to voltages to be supplied to the scanning driving IC. The LCD controller 136 drives each driving IC according to the image data stored in the memory 138 based on directions from the CPU 135.
[0109] The pixel arrangement of the liquid crystal display element 100 is represented by a matrix comprising the plurality of scanning electrodes 113 (R1, R2 . . . Rm in FIG. 2) and the plurality of signal electrodes 114 (C1, C2 . . . Cn in FIG. 2) ("m" and "n" being a natural number) as shown in FIG. 2. The scanning electrodes R1, R2 . . . Rm are connected to output terminals of the scanning driving IC 131, and the signal electrodes C1, C2 . . . Cn are connected to output terminals of the signal driving IC 132.
[0110] The scanning driving IC 131 is connected to the scanning electrodes R1, R2 . . . Rm as described above, to the controller CONT and to the power source 140. The driving IC 131 applies a driving voltage including a reset voltage (+V1 or -V1), a selection signal voltage (+V2 or -V2) and a maintaining voltage (+V3 or -V3)) to the scanning electrodes R1, R2 . . . Rm.
[0111] The reset voltage is output, for example, as a positive reset pulse +V1 of +40V or a negative reset pulse -V1 of -40V. The selection signal voltage is output, for example, as a positive selection pulse +V2 of +15V or a negative selection pulse -V2 of -15V, while the maintaining voltage is output, for example, as a positive maintaining pulse +V3 of +25V or a negative maintaining pulse -V3 of -25V. These voltages are output from the scanning driving IC 131.
[0112] Voltage stabilizing condensers C connected to the ground(GND) corresponding to said voltages are connected to connection lines for supplying the voltages +V1, +V2 and +V3, and -V1, -V2 and -V3 to the scanning electrodes 113. The logical power source connected to the scanning driving IC 131 is provided for supply of power to the scanning driving IC 131.
[0113] The signal driving IC 132 is connected, as described above, to the signal electrodes C1, C2 . . . Cn, to the controller CONT and to the power source 140. A voltage (rewriting signal voltage (+V4, -V4)) output from the power source 140 according to directions from the controller CONT is applied to the signal electrodes C1, C2 . . . Cn, respectively.
[0114] The rewriting signal voltage is output as positive signal pulses +V4 of +3V and negative signal pulses -V4 of -3V from the signal driving IC 132.

[0115] Voltage stabilizing condensers C connected to a ground(GND) corresponding to said voltages are connected to connection lines for supplying the driving voltage (+V4, -V4) to the signal electrodes.
[0116] More specifically stated, the scanning driving IC 131 outputs the selection signal voltage to predetermined one among the scanning electrodes R1, R2 . . . Rm to bring it to a selective state while it outputs non-selection signals to other electrodes under directions from the controller CONT to bring them to a non-selective state. The scanning driving IC 131 successively applies the selection signal voltage to the scanning electrodes R1, R2 . . . Rm, while switching the electrodes. The application of the selection signal voltage to one scanning electrode is performed in a scanning period set for the scanning electrode.
[0117] On the other hand, the signal driving IC 132 simultaneously outputs the signals (rewriting signal voltages) corresponding to the image data to the signal electrodes C1, C2 . . . Cn according to directions from the controller CONT to rewrite each pixel on the scanning electrode in the selective state. For example, if a scanning electrode Ra is selected ("a" of the Ra is a natural number satisfying "a"<=m), pixels LRa-C1 . . . LRa-Cn corresponding to intersections between the scanning electrode Ra and the signal electrodes C1, C2 . . . Cn are rewritten at the same time. A voltage difference between the selection pulse voltage (selection signal voltage) applied to the scanning electrode and the signal pulse voltage (rewriting signal voltage) applied to the signal electrode in each pixel is a voltage for rewriting the pixel so that the pixel is rewritten according to the voltage.
[0118] The controller CONT is adapted to control the scanning driving IC 131 such that the driving voltage to be applied to the scanning electrodes R1, R2 . . . Rm in scanning operation in each frame for matrix driving of the liquid crystal display element 100 has a single polarity in each frame and the polarity of the driving voltage is reversed in every frame.
[0119] More specifically stated, when scanning is performed in odd-numbered frames, the scanning driving IC 131 successively applies the positive reset pulse voltage +V1, the positive selection pulse voltage +V2 and the positive maintaining pulse voltage +V3 to each scanning electrode R1, R2 . . . Rm while the signal driving IC 132 applies the signal pulse +-V4 to each signal electrode C1, C2 . . . Cn.
[0120] When scanning is performed in even-numbered frames, the scanning driving IC 131 successively applies the negative reset pulse voltage -V1, the negative selection pulse voltage -V2 and the negative maintaining pulse voltage -V3 to each scanning electrode R1, R2 . . . Rm while the signal driving IC 132 applies the signal pulse +-V4 to each signal electrode C1, C2 . . . Cn (see FIGS. 6 to 8).
[0121] In the foregoing operation, the application period Tsp of the selection pulse voltage (selection signal voltage)(+V2 or -V2) is [1/2] the scanning period Tss and the signal pulse +-V4 is a voltage which is changed in polarity within the scanning period Tss and effective values of positive and negative voltages thereof are substantially equal to each other within the scanning period Tss.
[0122] Further the signal pulse is such that each of total of period(s) of the positive voltage and total of period(s) of the negative voltage within the scanning period Tss is as long as the application period Tsp of the selection pulse.
[0123] As described above, the controller CONT controls the scanning driving IC 131 such that the application period Tsp of the selection pulse (+V2 or -V2) is [1/2] the scanning period Tss and controls the signal driving IC 132 such that the signal pulse +-V4 is a voltage which is changed in polarity within the scanning period Tss; the effective values of the positive and negative voltages of the signal pulse are substantially equal to each other within the scanning period Tss; and the signal pulse is such that each of total of period(s) of the positive voltage and total of period(s) of the negative voltage within the scanning period is as long as the application period of selection pulse (+V2, -V2). This matter will be described in more detail in respect of driving principle and example of basic driving.
[0124] The signal pulse voltage+-V4 is a rectangular pulse voltage which has a duty ratio of 50% and the absolute values of positive and negative voltages (+V4, -V4) are identical with each other.
[0125] In this driving device, the power source 140 can supply both positive and negative voltages at least all the time during driving operation. The driving voltage is applied to the scanning electrodes R1, R2 . . . Rm by the scanning driving IC connected to the power source 140.
[0126] However, the supply of power is not limited to the above. The driving voltage may be applied to the scanning electrodes R1, R2 . . . Rm by the scanning driving IC connected to a power source which can switch output voltages from positive to negative and vice versa.
[0127] FIGS. 4 and 5 show another example of structure of a driving circuit. In the structure of the circuit shown in FIGS. 4 and 5, a power source switching circuit 141 is provided between the power source 140 and the scanning driving IC in the circuit structure shown in FIG. 3.
[0128] In the structure of the circuit shown in FIGS. 4 and 5, the power source 140 and the power source switching circuit 141 constitutes a power source 140' which can switch positive and negative of output voltage.
[0129] The power source 140' is connected to the controller CONT and has 4 switching elements SW1 to SW4.
[0130] The elements SW1 to SW4 can be simultaneously switched under directions from the controller

CONT to a state of applying a positive driving voltage (side 1 in the drawing) or to a state of applying a negative driving voltage (side 2 in the drawing). When the switching elements are in the state of side 1, the power source 140' can supply positive voltages +V1, +V2, +V3 from the power source 140 to the scanning driving IC 131. On the other hand, when the switching elements are in the state of side 2, the power source 140' can supply negative voltages -V1, -V2, -V3 from the power source 140 to the scanning driving IC 131.
[0131] In the driving device having the circuit structure shown in FIGS. 4 and 5, the controller CONT can control the power source 140' and the scanning driving IC 131 so that the driving voltage to be applied to the scanning electrodes 113 by switching from positive voltages +V1, +V2, +V3 to negative voltages -V1, -V2, -V3 or vice versa is given a single polarity in each frame, and polarity inversion is effected in every frame. According to the driving device, the driving of liquid crystal display element can be realized by a simple circuit structure. FIG. 4 shows the state of odd-numbered frames (plus frames) in which the switching elements SW1 to SW4 are switched to the side 1. FIG. 5 shows the state of even-numbered frames (minus frames) in which the elements SW1 to SW4 are switched to the side 2.
[0132] An image can be rewritten usually by successively selecting all scanning lines. When an image is partially rewritten, specific scanning lines alone are successively selected in a way to include a part to be rewritten. Thereby only the required part can be rewritten in a short time. In the circuit structure shown in FIGS. 4 and 5, the voltages to be supplied to the scanning driving IC is [1/2] the voltages in the structure in FIG. 3. Consequently the scanning driving IC which is inexpensive and which is relatively low in voltage resistance as compared with the structure of FIG. 3 can be used.
[0133] (Driving Principle and an Example of Basic Driving, see FIGS. 6 to 11)
[0134] The basic principle of the method of driving the liquid crystal display element 100 is first described. Hereinafter, this matter is explained with reference to specific example using pulse waveforms. However, the driving method is not limited to these waveforms.
[0135] FIG. 6(A) shows an example of basic driving waveform in odd-numbered frame (plus frame) which is output from the scanning driving IC 131 to each scanning electrode, and FIG. 6(B) shows an example of basic driving waveform in even-numbered frame (minus frame) which is output from the scanning driving IC 131 to each scanning electrode.
[0136] FIGS. 7 and 8 show waveforms of voltages which are output from the scanning driving IC 131 to each scanning electrode 113 (row electrode), a waveform of voltage which is output from the signal driving IC 132 to one signal electrode (column electrode), and waveforms of voltages as applied to the liquid crystals (indicated as LCD 1 to LCD 28 in the drawing) corresponding to pixels by these voltages. FIG. 7 shows waveforms of voltages in odd-numbered frame, and FIG. 8 shows waveforms of voltages in even-numbered frame.
[0137] FIGS. 7 and 8 indicate an example of basic driving in which a selection pulse voltage (selection signal voltage) is successively output to the plurality of scanning electrodes 113 (illustrated as 28 row electrodes 1, 2-28 in the drawings) and a signal pulse (rewriting signal voltage) is output from one signal electrode (depicted as a column b in the drawings, the "b" being a natural number satisfying b<=n) which is one of the plurality of signal electrodes 114 (a plurality of column electrodes).
[0138] The waveform of signal pulse output from the column b shown in the drawings is a waveform capable of successively outputting a pulse which selects the selective reflective state of the liquid crystal in any of scanning periods Tss. It is possible to output any of a waveform of signal pulse selecting a transparent state, a waveform of signal pulse selecting a selective reflective state and a waveform of signal pulse selecting a mixed state (mixture of these states) from the column b. This matter will be described in more detail later.
[0139] Indicated at LCD 1, 2 to 28 in the drawings are liquid crystals corresponding to the pixels intersectionally formed between the scanning electrodes (rows 1, 2-28) and the signal electrode (column b), and are waveforms of voltages applied to the liquid crystals corresponding to the pixels. A cross-talk pulse due to the signal pulse applied to the signal electrode is applied to the liquid crystals. FIGS. 7 and 8 indicate, in thick lines, ranges to which the cross-talk pulse is applied. This matter will be explained in detail later.
[0140] In this driving, as described above, the driving voltage to be applied to the scanning electrodes (rows 1, 2 to 28) in scanning is given a single polarity in each frame and the polarity is reversed in every frame. For example, the driving voltage is given a single polarity in scanning in one frame, namely until the scanning operation in one frame is completed, using the first scanning electrode (row 1) to the last scanning electrode (row 28). Then the polarity of the driving voltage is reversed for scanning in next one frame.
[0141] A driving period is roughly divided into a reset period Trs, a selection period Ts, a maintaining period Trt and a display period Ti. The selection period Ts is subdivided into a selection pulse application period (application period of selection signal voltage) Tsp, a pre-selection period Tsz and a post-selection period Tsz'. The reset period Trs and the maintaining period Trt are, for instance, 48 ms. The selection period Ts is, for example, 0.6 ms. The pre-selection period Tsz and the post-selection period Tsz' are both, for

example, [1/3] (0.2 ms) the selection period Ts (0.6 ms). The scanning period Tss is [1/3] (0.2 ms) the selection period Ts (0.6 ms). The selection pulse application period Tsp is [1/2] (0.1 ms) the scanning period Tss as described above.
[0142] As illustrated in FIGS. 6 to 8, in basic driving waveforms, a reset pulse (positive pulse +V1 in odd-numbered frames and negative pulse -V1 in even-numbered frames) is applied in the reset period Trs. In the selection period Ts, a selection pulse (positive pulse +V2 in odd-numbered frames and negative pulse -V2 in even-numbered frames) is applied in the selection pulse application period Tsp. In the scanning period Tss including the period Tsp, a signal pulse +-V4 is applied from the signal driving IC 132. The signal pulse +-V4 is determined based on the image data. As described above, the signal pulse +-V4 is a rectangular pulse which has a duty ratio of 50% and in which the absolute values of positive and negative voltages (+V4, -V4) are identical with each other. In the basic driving waveform, the voltage is zero in the pre-selection period Tsz and the post-selection period Tsz'. Further, a maintaining pulse (positive pulse +V3 in odd-numbered frames, and negative pulse -V3 in even-numbered frames) is applied in the maintaining period Trt.
[0143] The liquid crystal operates as follows. First, when the reset pulse of +V1 (odd-numbered frames) or -V1 (even-numbered frames) is applied in the reset period Trs, the liquid crystal is reset to a homeotropic state. The reset period Trs proceeds to the selection pulse application period Tsp via the pre-selection period Tsz (during which the liquid crystal becomes slightly retwisted). The waveform of the pulse to be applied to the liquid crystal in the period Tsp is varied with a pixel finally selecting a planar state or with a pixel finally selecting a focal conic state.
[0144] FIGS. 6 to 8 show cases of selecting a planar state. When a focal conic state is to be selected, the phase of the signal pulse is shifted to an extent corresponding to a half-period compared with the case of selecting a planar state.
[0145] The case of selecting a planar state will be described. In this case, in the selection pulse application period Tsp, a voltage of [(+V2)-(-V4)] in odd-numbered frames or a voltage of [(-V2)-(+V4)] in even-numbered frames is applied to the liquid crystal to bring the liquid crystal to a homeotropic state again. Thereafter the liquid crystal becomes slightly retwisted in the post-selection period Tsz'. Then when the maintaining pulse of +V3 (odd-numbered frames) or -V3 (even-numbered frames) is applied in the maintaining period Trt, the liquid crystal having become slightly retwisted in the post-selection period Tsz' becomes further loose by application of the maintaining pulse and is brought to a homeotropic state.
[0146] The liquid crystal in the homeotroic state is brought to a planar state by change-over to voltage zero and is fixed in the planar state.
[0147] On the other hand, when a focal conic state is finally selected, a voltage of [(+V2)-(+V4)] in odd-numbered frames or a voltage of [(-V2)-(-V4)] in even-numbered frames is applied in the selection pulse application period Tsp. In post-selection period Tsz', the liquid crystal becomes retwisted and a state having a helical pitch spreading approximately twice.
[0148] Subsequently, the maintaining pulse of +V3 (odd-numbered frames) or -V3 (even-numbered frames) is applied in the maintaining period Trt. The liquid crystal having become slightly retwisted in the post-selection period Tsz' is brought to a focal conic state by application of the maintaining pulse. The liquid crystal in the focal conic state is fixed in the focal conic state even by change-over to voltage zero.
[0149] According to the above-described method and device for driving the liquid crystal display element and liquid crystal display apparatus, when the scanning operation is performed in each frame for matrix driving of the liquid crystal display element 100, the driving voltage to be applied to the scanning electrodes 113 is given a single polarity in each frame and the polarity is reversed in every frame, whereby the state of single polarity of the voltage to be applied to the liquid crystal 116 in each frame can continuously last for a prolonged period of time. Consequently compared with use of, for example, an alternating voltage whose polarity of voltage waveform is periodically changed as a voltage to be applied to the liquid crystal 116, it is possible to reduce a waveform repeating frequency of voltage to be applied to the liquid crystal 116, and the value of driving voltage to be applied to the scanning electrode 113 can be decreased by [1/2], thereby correspondingly lowering the consumption of power for driving the liquid crystal display element 100. Namely the liquid crystal display element 100 can be driven by reduced power consumption.
[0150] As set forth above, the final display state of the liquid crystal can be selected by the pulse to be applied to the liquid crystal in the selection pulse application period Tsp. An intermediate tone display can be achieved by adjusting a voltage value of pulse, pulse width and/or phase, more specifically by adjusting the waveform of the signal pulse to be applied to the signal electrode in accordance with image data.
[0151] The following description will be made about an intermediate tone display performed by changing a phase of the signal pulse to be applied to the signal electrode.
[0152] FIGS. 9 to 11 show a waveform of the selection pulse voltage which is output to a single row a selected from the rows 1 to 28, a waveform of the signal pulse voltage which is output to the column b and a waveform of a voltage applied to the liquid crystal LCDx by the selection pulse voltage and the signal pulse voltage in odd-numbered frames (plus frames).

[0153] FIG. 9 indicates waveforms for finally setting the liquid crystal in a maximum selective reflective state. FIG. 10 illustrates waveforms for finally setting the liquid crystal in an intermediate tone display state. FIG. 11 shows waveforms for finally setting the liquid crystal in a transparent state.
[0154] FIG. 12(A), FIG. 12(B), and FIG. 12(C) show the waveform of the selection pulse voltage to be output to the row a, the waveform of the signal pulse voltage to be output to the column b, and the waveform of the voltage to be applied to the liquid crystal LCDx, chiefly those in the selection period, these views being enlarged from those shown in FIG. 10, FIG. 9 and FIG. 11, respectively.
[0155] As shown in FIG. 12(A) to FIG. 12(C), the signal pulse of $\pm V4$ to be applied to the column b is such that a total of minus period(s) (or total of plus period(s)) of the signal pulse voltage during the signal pulse application period Tw (scanning period Tss) is as long as the selection pulse application period Tsp. Accordingly, it is possible that a rise or fall timing of the signal pulse to be applied to the column b in synchronization with application of the selection pulse to the row a is shifted within a period from zero to the Tsp ([1/2] the scanning period Tss) (see t1 (or t2) in FIG. 12(A)), thereby changing a width of each of highest portion $|V2+V4|$ and lowest portion $|V2-V4|$ of the pulse voltage to be applied to the liquid crystal LCDx within the selection pulse application period and controlling the final state of the liquid crystal.
[0156] As shown in FIG. 12(A), in the waveform of the voltage for selecting the intermediate tone display state of the liquid crystal, a total of application periods of highest portion $|V2+V4|$ and lowest portion $|V2-V4|$ of the pulse voltage to be applied to the liquid crystal LCDx within the selection pulse application period is equal to the selection pulse application period Tsp. As shown in FIG. 12(B), in the waveform of the voltage for selecting the selective reflective state of the liquid crystal, a width of the highest portion $|V2+V4|$ of the pulse voltage to be applied to the liquid crystal LCDx within the selection pulse application period is equal to the width of the selection pulse application period Tsp. As shown in FIG. 12(C), in the waveform of voltage for selecting the transparent state of the liquid crystal, a width of the lowest portion $|V2-V4|$ of the pulse voltage to be applied to the liquid crystal LCDx within the selection pulse application period is equal to the width of the selection pulse application period Tsp.
[0157] The operation in the minus frame in which a minus voltage is applied to the rows is the same in the plus frame except that the polarity of the voltage to be applied to the rows and the polarity of the voltage to be applied to the columns are reversed.
[0158] As indicated with thick lines in FIGS. 7 and 8, any of the waveforms of the voltages to be applied to the liquid crystals LCD1, LCD2 suffers a cross-talk due to the signal pulse to be applied to the signal electrode.
[0159] However, the waveform of the signal pulse to be applied to the column b is a rectangular pulse waveform which has a duty ratio of 50% and in which the absolute values of positive and negative voltages are identical with each other. In any waveform for selecting a display state of the liquid crystal, the voltage applied to the liquid crystal in the reset period and the voltage applied to the liquid crystal in the maintaining period are constant, respectively as shown in FIG. 12(A) to FIG. 12(C), since an effective voltage is $\sqrt{[(V1+V4)^2+(V1-V4)^2]/2}$ in the reset period and an effective voltage is $\sqrt{[(V3+V4)^2+(V3-V4)^2]/2}$ in the maintaining period.
[0160] As described above, if the selection pulse voltage to be applied to the row a is a voltage whose application period Tsp is [1/2] the scanning period Tss and the signal pulse voltage to be applied to the column b has a rectangular pulse waveform which has a duty ratio of 50% and in which the absolute values of positive and negative voltages are identical with each other, voltages applied to the liquid crystals LCD 1, LCD 2 to LCD 28 corresponding to pixels due to the cross-talk can be made substantially constant, whereby a shadowing occurring in image display due to the cross-talk can be suppressed.
[0161] The foregoing embodiments use a signal pulse which has a duty ratio of 50% and in which a positive or negative continuous time is as long as Tsp. However, if a duty ratio is 50%, an effect of suppressing the shadowing can be achieved without the feature that a positive or negative continuous time is as long as as Tsp. In that case, the signal pulse may be output as separated into two while maintaining a duty ratio at 50%.
[0162] However, this case involves twice the inversion frequency of signal pulse and twice the power consumption of the display element (display panel) arising from the signal pulse. FIG. 13(A) to FIG. 13(C) show an example of signal pulse wherein continuous time T1 or T2 of positive or negative voltage is not as long as the selection signal application period Tsp. In this example, intermediate tone display state can be selected by applying signal pulse shown in FIG. 13(A) in which total sum of the continuous times T1 and T2 is kept to the period Tsp. By varying the ratio of the continuous times T1 and T2 with keeping the sum of the times T1 and T2 to the period Tsp, various tone display states including the maximum selective reflective display state (the planar state: T1=0, T2=Tsp: FIG. 13(B)) and the transparent state (the focal conic state: T1=Tsp, T2=0: FIG. 13(C)) can be selected.
[0163] Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and the scope of the present invention being limited only by the terms of the appended claims.

Liquid-crystal display devices

Claims of corresponding document: **US2003156089**

Translate this text

What is claimed is:

1. A liquid crystal display apparatus comprising:
a liquid crystal display element that includes a layer of a liquid crystal exhibiting a cholesteric phase, and a plurality of scanning and signal electrodes extending across each other with the liquid crystal layer therebetween for performing display utilizing a selective reflection capability of the liquid crystal; and
a driving device for driving the liquid crystal display element by simple matrix driving,
wherein the driving device is configured such that (1) a driving voltage of single polarity including a selection signal voltage is applied to the scanning electrodes in each frame, and the polarity of the driving voltage is reversed in every frame; (2) the scanning electrodes are successively brought to a selected state by applying the selection signal voltage to each scanning electrode in a scanning period set for the scanning electrode, while a rewriting signal voltage corresponding to each scanning electrode in the selected state is applied to each signal electrode in synchronization with application of the selection signal voltage to the scanning electrode; and (3) an application period of the selection signal voltage to the scanning electrode is half of the scanning period.

2. The liquid crystal display apparatus according to claim 1, wherein the rewriting signal voltage to be applied to the signal electrode is changed in polarity within the scanning period and effective values of positive and negative voltages of the rewriting signal voltage are substantially equal to each other within the scanning period.

3. The liquid crystal display apparatus according to claim 1, wherein the rewriting signal voltage to be applied to the signal electrode is such that sum total of total of period(s) of positive voltage and total of period(s) of negative voltage is as long as the scanning period.

4. The liquid crystal display apparatus according to claim 1, wherein the driving device is capable of varying a density of an image to be finally displayed by adjusting a phase of the rewriting signal voltage to be applied to the signal electrode in synchronization with application of the selection signal voltage to the scanning electrode.

5. The liquid crystal display apparatus according to claim 1, wherein the liquid crystal display element can maintain a display without application of voltage.

6. The liquid crystal display apparatus according to claim 1, wherein the driving device applies a reset voltage to each scanning electrode for bringing the liquid crystal to a homeotropic state before a selection period while the selection signal voltage is applied.

7. The liquid crystal display apparatus according to claim 6, wherein the driving device applies a maintaining voltage to each scanning electrode for eastablishing a state of the liquid crystal to be selected by the selection signal voltage after application of the selection signal voltage to the scanning electrode.

8. The liquid crystal display apparatus according to claim 1, wherein the driving device performs an interlace driving in which one frame is separated into a plurality of fields.

9. The liquid crystal display apparatus according to claim 1, wherein the driving device performs a progressive driving in which the plurality of scanning electrodes are succesively scanned in each frame.

10. The liquid crystal display apparatus according to claim 1, wherein the driving device includes a power circuit which can switch positive and negative of output voltage and a scanning driving IC connected between the power circuit and the plural scanning electrodes, and wherein the polarity of the driving voltage to be applied to the scanning electrode can be reversed by change-over of the positive and negative of output voltage of the power circuit in every frame.

11. The liquid crystal display apparatus according to claim 10, wherein the power circuit includes a power source having a plurality of output terminals and a circuit for switching the terminals to be connected to the scanning driving IC.

12. The liquid crystal display apparatus according to claim 1, wherein the liquid crystal display element is a laminate type element having a plurality of laminated liquid crystal layers, wherein the driving device has a scanning driving IC connected to the scanning electrodes, and a signal driving IC connected to the signal electrodes, and wherein any one of the scanning driving IC and the signal driving IC is used in common for driving each of the liquid crystal layers.

13. A liquid crystal display apparatus comprising:
a liquid crystal display element that includes a layer of a liquid crystal exhibiting a cholesteric phase, and a plurality of scanning and signal electrodes extending across each other with the liquid crystal layer therebetween; and
a driving device for driving the liquid crystal display element by simple matrix driving,
wherein the driving device is configured such that (1) a driving voltage of single polarity including a selection signal voltage, a reset voltage and a maintaining voltage is applied to the scanning electrodes in each frame, and the polarity of the driving voltage is reversed in every frame; (2) the scanning electrodes are successively brought to a selected state by applying the selection signal voltage to each scanning electrode in a scanning period set for the scanning electrode, while a rewriting signal voltage corresponding to each scanning electrode in the selected state is applied to each signal electrode in synchronization with application of the selection signal voltage to the scanning electrode; (3) the reset voltage is applied to the scanning electrode to bring the liquid crystal to a homeotropic state before applying the selection signal voltage, and the maintaining voltage is applied to the scanning electrode to establish a state of the liquid crystal to be selected by the selection signal voltage after applying the selection signal voltage; and (4) the rewriting signal voltage to be applied to the signal electrode is changed in polarity within the scanning period, and effective values of positive voltage and negative voltage of the rewriting signal voltage are substantially equal to each other within the scanning period.

14. The liquid crystal display apparatus according to claim 13, wherein the liquid crystal display element can maintain a display without application of voltage.

15. The liquid crystal display apparatus according to claim 13, wherein the driving device is configured such that a period is set for bringing the voltage to be applied to the scanning electrode to 0V between application of the reset voltage and application of the selection signal voltage and/or between application of the maintaining voltage and application of the selection signal voltage.

16. The liquid crystal display apparatus according to claim 13, wherein the driving device is capable of varying a density of an image to be finally displayed by adjusting a phase of the rewriting signal voltage to be applied to the signal electrode in synchronization with application of the selection signal voltage to the scanning electrode.

17. The liquid crystal display apparatus according to claim 13, wherein the reset voltage and the maintaining voltage to be applied to the scanning electrode are different in voltage value from the selection signal voltage, respectively.

18. A liquid crystal display apparatus comprises a liquid crystal display element, and a driving device for driving the liquid crystal display element by simple matrix driving, wherein the liquid crystal display element includes a liquid crystal layer, and has a plurality of scanning electrodes and a plurality of signal electrodes extending across each other with the liquid crystal layer therebetween, wherein the driving device is configured such that a driving voltage of single polarity including a selection signal voltage is applied to the scanning electrodes in each frame, and the polarity of the driving voltage is reversed in every frame; the scanning electrodes are successively brought to a selected state by applying the selection signal voltage to each scanning electrode in a scanning period set for the scanning electrode, while a rewriting signal voltage corresponding to each scanning electrode in the selected state is applied to each signal electrode in synchronization with application of the selection signal voltage to the scanning electrode; and the rewriting signal voltage to be applied to the signal electrode is changed in polarity within the scanning period, and effective values of positive voltage and negative voltage of the rewriting signal voltage are substantially equal to each other within the scanning period.

19. The liquid crystal display apparatus according to claim 18, wherein the driving device applies the

rewriting signal voltage corresponding to each scanning electrode in the selected state to each signal electrode in synchronization with application of the selection signal voltage to the scanning electrode, and an application period of the selection signal voltage to the scanning electrode is [1/2] the scanning period.

20. The liquid crystal display apparatus according to claim 18, wherein the driving device includes a power circuit which can switch positive and negative of output voltage and a scanning driving IC connected between the power circuit and the plural scanning electrodes, and the power circuit includes a power source having a plurality of output terminals and a circuit for switching the terminals to be connected to the scanning driving IC, and wherein the circuit for switching the terminals reverses the polarity of the driving voltage to be applied to the scanning electrode by changing the terminals to be connected to the scanning driving IC in every frame.

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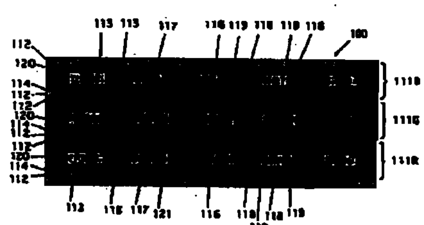
权利要求书 2 页 说明书 19 页 附图 13 页

[54] 发明名称

液晶显示设备

[57] 摘要

本发明涉及一种用于驱动液晶显示设备的矩阵驱动方法。该液晶显示器件包括表现胆甾相的液晶层，扫描电极以及信号电极。所述方法包括：在每一帧中将包括选择信号电压的单一极性的驱动电压施加到扫描电极上，且使该驱动电压的极性在每一帧进行翻转。通过在为扫描电极而设的扫描周期中向每个扫描电极施加选择信号电压，使扫描电极依次进入选中状态，同时，向每个信号电极施加对应于选中状态的每个扫描电极的改写信号电压。扫描电极上的选择信号电压施用周期为1/2的扫描周期。使施加到信号电极的改写信号电压在扫描周期中改变极性，其中在扫描周期中该改写信号电压的正、负电压有效值彼此基本相同，以及将要施加到信号电极上的改写信号电压的正电压周期总数设置为与负电压周期总数的总和同扫描周期一样长。



1. 一种用于驱动液晶显示设备的矩阵驱动方法，该液晶显示设备包括：

一包含有表现出胆甾相的液晶层的液晶显示器件，和相互交叉延伸的许多扫描电极和信号电极，它们将液晶层夹在中间，利用液晶的选择性反射性能来实现显示；和

一驱动装置，用于驱动液晶显示器件，

所述矩阵驱动方法包括如下步骤：

在每一帧中将选择信号电压的单一极性的驱动电压施加到扫描电极，且使该驱动电压的极性在每一帧进行翻转；

通过在为扫描电极而设的扫描周期中向每个扫描电极依次施加选择信号电压，使扫描电极依次进入选中状态，同时，同步于对扫描电极施加选择信号电压，向每个信号电极施加对应于选中状态的每个扫描电极的改写信号电压；

将向扫描电极施用选择信号电压的施用周期设置为扫描周期的一半；

使施加到信号电极的改写信号电压在扫描周期中改变极性，其中在扫描周期中该改写信号电压的正、负电压有效值彼此基本相同，以及

将要施加到信号电极上的改写信号电压的正电压周期总数设置为与负电压周期总数的总和同扫描周期一样长。

2. 根据权利要求1的矩阵驱动方法，其中所述驱动装置能够通过与向扫描电极施用选择信号电压相同步，调节要施加给信号电极的改写信号电压的相位，从而改变最终显示图象的密度。

3. 根据权利要求1的矩阵驱动方法，其中所述液晶显示器件能够不用施加电压维持显示。

4. 根据权利要求1的矩阵驱动方法，其中所述驱动装置在施加选择信号电压的选择周期之前，向每个扫描电极施加一个复位电压，使液晶进入初始状态。

5. 根据权利要求4的矩阵驱动方法，其中所述驱动装置在向扫描电极施加了选择信号电压之后，向每个扫描电极施加一个维持电压，以建立起一种由选择信号电压选中的液晶状态。

6. 根据权利要求1的矩阵驱动方法，其中所述驱动装置执行一种将一帧分

为多个段的交叉驱动。

7. 根据权利要求1的矩阵驱动方法，其中所述驱动装置执行一种在每一帧中依次扫描许多扫描电极的渐进驱动。

8. 根据权利要求1的矩阵驱动方法，其中所述驱动装置包括一可以切换输出电压正负的电源电路和连接在电源电路和许多扫描电极之间的扫描驱动集成电路，其中可以通过在每一帧中转换电源电路的正负输出电压来翻转施加到扫描电极的驱动电压的极性。

9. 根据权利要求8的矩阵驱动方法，其中电源电路包括具有多个输出端的电源和一个可以切换连接扫描驱动集成电路终端的电路。

10. 根据权利要求1的矩阵驱动方法，其中液晶显示器件是具有多个层压型液晶层的层压型器件，其中驱动装置具有连接扫描电极的扫描驱动集成电路，和连接信号电极的信号驱动集成电路，并且其中任一扫描驱动集成电路和信号驱动集成电路能通用以驱动每个液晶层。

11. 根据权利要求5的矩阵驱动方法，其中驱动装置配置为在施用复位电压和施用选择信号电压之间和/或在施用维持电压和施用选择信号电压之间，设立一个将施加到扫描电极上的电压置零的周期。

12. 根据权利要求5的矩阵驱动方法，其中要施加到扫描电极上的复位电压和维持电压的电压值分别异于选择信号电压。

液晶显示设备

相关申请的交叉引用

本申请以2002年2月18日在日本申请的申请号为NO.2002－87192的日本专利申请作为基础，该申请的全部内容由此被结合参考。

技术领域

本发明涉及一种液晶显示器件的驱动方法，一种液晶显示器件的驱动装置以及一种液晶显示设备。

背景技术

通常液晶显示设备包括液晶显示器件和驱动液晶显示器件的装置。

液晶显示器件主要包括一对基板和置于基板间的液晶层。通过向液晶层施加一预定的驱动电压，以控制液晶分子的排列，由此通过对入射到液晶器件上的光进行调制来实现所需图象的显示。

大量种类的液晶显示器件已经得到推广。近年来，进行的研究为一种包含一种手征性向列液晶合成物的液晶显示器件，该合成物通过将手征性材料加入到向列液晶中制备而成，由于手征性材料的缘故，导致该合成物在室温下呈胆甾相。

这种液晶显示器件是很有用的，例如，利用该手征性液晶合成物的选择性反射性能，作为一种反射型液晶显示器件。

在这种反射型液晶显示器件中，可以通过施加一个高的或低的脉冲电压，将液晶合成物切换到平面状态（彩色状态）或焦锥状态（透明状态），实现图像显示。

即使停止施加这种脉冲电压后，该液晶合成物仍能保持平面状态或焦锥状态，换言之,该液晶合成物能表现出所谓的双稳态性能，或者能实现记忆效果，因此在停止施加电压之后，仍能保持图象显示。

反射型液晶显示器件可以实现利用黑色或类似颜色背景的单色

(mono-color)图象显示，双色图象显示或全色图象显示。

例如，为了实现全色图象的显示，可以使用一种层压型液晶显示器件，它包括至少三个液晶层，也就是可以实现红色显示的红色液晶层，可以实现绿色显示的绿色液晶层和可以实现蓝色显示的蓝色液晶层。

当这种层压型液晶显示器件的至少一个液晶层维持在平面状态(彩色状态）时，可以显示红，绿，蓝或其它颜色。当层压型液晶显示器件维持在焦锥状态（透明状态）时，可以显示黑色或类似的背景色。

在这种液晶显示器件中，通常在中间保持有液晶层的一对基板上形成并放置电极，使得基板上形成电极的表面相互对置。

例如，液晶显示器件具有一个包括大量像素的图象显示区域，这些像素由使用相互对置的许多扫描电极和许多信号电极的矩阵驱动系统驱动。

在这样的液晶显示器件中，例如，许多条状扫描电极（或信号电极）在两基板之一的预定方向上以指定的间距相互平行地延伸开来，而许多条状信号电极（或扫描电极）则在另一块基板的预定方向上以指定的间距相互平行延伸。当从一平面观察时，这两组电极相互交叉延伸。每一个像素对应于这对基板上电极相互交叉的部位上。

这对基板上形成的每个电极都与液晶显示器件的驱动装置相连。当从与电极相连的驱动装置向基板上的电极施加一预定的驱动电压时，就驱动液晶以显示所要的图象。

液晶显示器件可以使用一种例如简单的矩阵驱动方法驱动。

在这种简单的矩阵驱动方法中，用于驱动液晶显示器件的装置包括，如一个扫描驱动集成电路，它连接到许多扫描电极上并能给扫描电极提供预定的选择信号电压，和一个信号驱动集成电路，它连接到许多信号电极上并能向信号电极提供预定的改写信号电压。

通过从与许多扫描电极相连的扫描驱动集成电路向每个扫描电极依次施加预定的选择信号电压，扫描电极依次进入选中状态，同时，同步于从与许多信号电极相连的信号驱动集成电路向每个扫描电极施加选择信号电压，向每个信号电极施加预定的改写信号电压，由此向液晶施加一个对应于选择信号电压和改写信号电压之间电势差的电压，从而驱动液晶。

当用这样的简单矩阵驱动方法驱动液晶时，出于增加液晶寿命等观点，施

加到液晶的电压可能是例如一种电压波形极性在每一帧作周期性改变的交变电压（例如，包含电压波形极性周期性变化的矩形脉冲电压）。

然而，当把一个带有电压波形极性周期性变化的交变电压施加到也可用作电容器的液晶上时，随着该交变电压波形重复频率的增加，电流更容易在夹有液晶的电极间窜流，由此造成驱动液晶显示器件的能耗增加。

而且，由于对应于交变电压的电压在一帧内施加到扫描驱动集成电路上，所以就要求扫描驱动集成电路在交变电场中有能力经受对应于最大和最小电压压差的电压。

在这种简单矩阵驱动方法中，在选择信号电压施加到扫描电极的每个扫描周期内，将一改写信号电压与选择信号电压同步地施加到相应的要显示像素的信号电极上，并且将一个基于选择信号电压和改写信号电压的电压施加到相应的要显示像素的液晶上。在这一操作中，由改写信号电压将一电压施加到对应于非显示像素的液晶上。即出现了所谓的“串扰”。

由于在对应于这些像素的液晶中的串扰，例如，一个或多个要以高密度显示的像素以稍低密度显示出来，或者一个或多个要以低密度显示的像素以稍高密度显示出来。即一个如同阴影的图象出现在前述像素部分中。换言之，发生阴影现象。

发明内容

本发明的目的之一是提供一种液晶显示设备，包括一含有液晶的液晶显示器件，和一用于以矩阵驱动方式驱动液晶显示器件的驱动装置，该液晶显示设备能减少驱动液晶显示器件的能耗。

本发明的另一目的是提供一种液晶显示设备，包括一含有液晶的液晶显示器件，和一用于以矩阵驱动方式驱动液晶显示器件的驱动装置，该液晶显示设备在由于改写信号电压施加到信号电极上使液晶遭受串扰时，能在图象显示中抑制阴影的产生以显示较好的图象。

本发明的再一目的是提供一种液晶显示设备，包括一含有液晶的液晶显示器件，和一用于以矩阵驱动方式驱动液晶显示器件的驱动装置，该液晶显示设备能应用一种低电压阻抗的驱动集成电路来驱动液晶显示器件。

本发明提供以下的用于驱动液晶显示设备的矩阵驱动方法，该液晶显示设

备包括：

一包含有表现出胆甾相的液晶层的液晶显示器件，和相互交叉延伸的许多扫描电极和信号电极，它们将液晶层夹在中间，利用液晶的选择性反射性能来实现显示；和

一驱动装置，用于驱动液晶显示器件，

所述矩阵驱动方法包括如下步骤：

在每一帧中将选择信号电压的单一极性的驱动电压施加到扫描电极，且使该驱动电压的极性在每一帧进行翻转；

通过在为扫描电极而设的扫描周期中向每个扫描电极依次施加选择信号电压，使扫描电极依次进入选中状态，同时，同步于对扫描电极施加选择信号电压，向每个信号电极施加对应于选中状态的每个扫描电极的改写信号电压；

将向扫描电极施用选择信号电压的施用周期设置为扫描周期的一半；

使施加到信号电极的改写信号电压在扫描周期中改变极性，其中在扫描周期中该改写信号电压的正、负电压有效值彼此基本相同，以及

将要施加到信号电极上的改写信号电压的正电压周期总数设置为与负电压周期总数的总和同扫描周期一样长。通过本发明以下结合附图的详细描述，本发明的上述和其它目的、特征，方面和优点将变得更为清楚。

附图说明

图1是可以用简单矩阵驱动方法驱动的反射/层压型全色液晶显示器件结构的截面图。

图2是一例驱动电路的框图，它是向液晶显示层施加驱动电压的驱动装置的主要部分。

图3是图2中驱动电路具体结构的例子。

图4是图2中驱动电路具体结构的另一个例子，示出了开关部件转换到1侧的奇数帧（正帧）状态。

图5是图4中电路偶数帧（负帧）的状态，其中开关部件转换到2侧。

图6（A）是在奇数帧中从扫描驱动集成电路输出到每个扫描电极的基本驱动波形，图6(B）是偶数帧中从扫描驱动集成电路输出到每个扫描电极的基本驱动波形。

图7是在一个奇数帧中，从扫描驱动集成电路输出到扫描电极的电压波形，从信号驱动集成电路输出到一个信号电极的电压波形和施加到相应像素液晶上的电压波形。

图8是在一个偶数帧中，从扫描驱动集成电路输出到扫描电极的电压波形，从信号驱动集成电路输出到一个信号电极的电压波形和施加到相应像素液晶上的电压波形。

图9是在一个奇数帧中，输出到一个行电极（扫描电极）的选择脉冲波形，输出到一个列电极（信号电极）的信号脉冲波形和用于在最大选择性反射状态中最终选择液晶的这些电压施加到液晶上的波形。

图10是在一个奇数帧中，输出到一个行电极的选择脉冲波形，输出到一个列电极的信号脉冲波形和用于在中间态显示状态中最终选择液晶的这些电压施加到液晶上的波形。

图11是在一个奇数帧中，输出到一个行电极的选择脉冲波形，输出到一个列电极的信号脉冲波形和用于在透明状态中最终选择液晶的这些电压施加到液晶上的波形。

图12（A），图12（B）和图12（C）是主要在选择周期中图10，图9和图11中所示输出到行电极的选择脉冲波形，输出到列电极的信号脉冲波形和这些电压施加到液晶上的波形的放大部分。

图13（A）到图13（C）是一个信号脉冲的例子，其中正电压或负电压的持续时间T1或T2不同于选择信号施用周期Tsp。

具体实施方式

根据本发明优选实施例的液晶显示设备主要包括一液晶显示器件，和用于驱动液晶显示器件的驱动装置。液晶显示器件可包括表现出胆甾相(胆甾特性）的液晶层，并可利用液晶的选择性反射来实现显示。该器件具有许多扫描电极和许多信号电极，这些电极相互交叉延伸并将液晶层夹在其间。该驱动装置可以用简单矩阵驱动方法驱动液晶显示器件。

驱动装置设置如下：在每一帧中将包含选择信号电压的单一极性驱动电压施加到扫描电极，并且驱动电压的极性在每一帧进行翻转。

驱动装置还设置为通过在为扫描电极而设的扫描周期中向每个扫描电极施

加选择信号电压，使扫描电极依次进入选中状态，同时，与向扫描电极施加选择信号电压相同步，向各个信号电极施加对应于选中状态的每个扫描电极的改写信号电压。扫描电极的选择信号电压施用周期可为扫描周期的1/2（扫描周期的一半）。扫描周期是将选择信号电压施加到扫描电极上的周期。

在该液晶显示设备中，施加到扫描电极上用于对液晶显示器件矩阵驱动的每一帧扫描的驱动电压是单一极性的，并且在每一帧中极性翻转，这样在各自帧中施加到液晶上的电压的单一极性状态可以连续维持一个很长的时间周期。从而与使用电压波形极性在每一帧中周期性变化的交变电压相比，可减小施加到液晶的实际电压波形重复频率。

此外，施加到扫描电极上的驱动电压值可减小到原来的1/2，同时用于驱动液晶显示器件的能耗总量也可以相应降低。即驱动液晶显示器件的能耗会减小。而且考虑到与使用交变电压相比提供给扫描驱动集成电路的电压减少为原来的1/2，廉价且具有较低电压阻抗的扫描驱动集成电路也可以使用了。

用于液晶显示器件的表现出胆甾相的液晶范例包括那些在室温(如约25°C)下表现出胆甾相（胆甾特性）的液晶。表现出胆甾相的液晶包括，例如，可以自己表现出胆甾相的胆甾液晶和通过向向列液晶中加入手征性材料制备的手征向列液晶合成物。手征向列液晶合成物能对预定波长范围内的光进行选择性地反射，并可以实现记忆效果。通过改变所加入手征性材料的总量，可以很方便地对选择反射波长进行调节。

驱动液晶显示器件的驱动装置可以包括一个连接到许多扫描电极的扫描驱动集成电路，一个连接到许多信号电极的信号驱动集成电路，以及一个控制上述驱动集成电路的控制器。该控制器适于控制扫描驱动集成电路，以使一选择信号电压依次施加到扫描电极上使该电极进入选中状态，同时它适于控制信号驱动集成电路，以使一改写信号电压施加到每个信号电极上，特别是，同步于向每个扫描电极施加选择信号电压，将一对应于选中状态下的扫描电极的改写信号电压施加到信号电极上。

控制器能以如下方式控制扫描驱动集成电路：在对液晶显示器件矩阵驱动的每一帧扫描中，施加到扫描电极的驱动电压在各自帧中是单一极性的，并且在每一帧中进行极性翻转。

为了在每个像素上正确驱动表现胆甾相的液晶，在施加选择信号电压的预

定周期（选择周期）之前，在一个特定时间周期（复位周期），一个预定复位电压施加给扫描电极，以使液晶回复到初始状态。在这种情况下，选择信号电压必须有足够的电压将回复的液晶变到所需的状态。

在施加了选择信号电压之后，在一个特定时间周期（维持周期），一个用于建立起一种由选择信号电压所选择的液晶状态的预定维持电压施加给各个扫描电极。

在施加选择信号电压的选择周期中，在施加复位电压的复位周期之后并在施加选择信号电压之前，对一个特定周期（预选择周期），给扫描电极的驱动电压可能为0V，而在施加维持电压之前并在施加选择信号电压之后，对一个特定周期（过选择周期），给扫描电极的驱动电压也可能为0V。

当通过向许多扫描电极依次施加选择信号电压使各个扫描电极进入选中状态，同时，同步于向扫描电极施加选择信号电压，向对应于选中状态下的扫描电极施加一改写信号电压时，该改写信号电压可在扫描周期内变化极性，并且在扫描周期内该改写信号电压的正、负电压有效值彼此基本相同。

根据这些特征，当由于改写信号电压施加到信号电极使相应像素的液晶受到串扰影响时，由于串扰施加给液晶的电压可以变得基本恒定。

但是，在这种情况下，如果选择信号电压的施用周期与扫描周期一样长，要显示的像素就不会由在扫描周期中变化极性的改写信号电压适当地显示出来。

鉴于上述情况，当向用于矩阵驱动的许多扫描电极和许多信号电极施加驱动电压时，将施加给扫描电极的扫描信号电压施用周期设为扫描周期的1/2是可取的。

如果实现以下特征，则要显示像素就能正确显示：选择信号电压的施用周期为扫描周期的1/2；在扫描周期内改写信号电压变化极性；在扫描周期内改写信号电压的正、负电压有效值彼此基本相等；每个正电压周期总数和负电压周期总数同选择信号电压的施用周期一样长。

以下内容亦由这些特征所得。当由于改写信号电压施加到信号电极使相应像素的液晶受到串扰影响时，由于串扰施加给相应像素液晶的电压可以变得基本恒定。由此，在液晶受到串扰影响时，能抑制图象中阴影的产生而得到较好的图象显示。而且，例如，通过改变改写信号电压的状态，每个像素可以显示为平面状态（选择性反射状态），焦锥状态（透明状态）或中间态状态（混合状

态)。

在液晶显示设备和包括扫描驱动集成电路，信号驱动集成电路和控制器的液晶显示器件驱动装置中，控制器适于控制信号驱动集成电路以使选择信号电压的施用周期调整为1/2扫描周期，并适于控制信号驱动集成电路以在扫描周期中改变改写信号电压的极性，使在扫描周期中正、负电压的有效值彼此基本相同，并允许改写信号电压使得在扫描周期内每个正电压周期总数和负电压周期总数与选择信号电压施用周期相等。

无论如何，对于在扫描周期中极性变化的改写信号电压来说，要求改写信号电压的施用周期要和扫描周期相等，在扫描周期中正、负电压的有效值彼此基本相等，并且在扫描周期中，每个正电压周期总数和负电压周期总数与选择信号电压的施用周期相等。

在扫描周期中具有50%的占空比，而且正、负电压的绝对值彼此相同的矩形脉冲电压可以作为改写信号电压的典型范例提出，其极性在扫描周期中发生变化，在扫描周期中正、负电压的有效值彼此基本相等，每个正电压周期总数和负电压周期总数与选择信号电压的施用周期相等，并且改写信号电压的施用周期和扫描周期一样长。

当选择信号电压的施用周期为1/2扫描周期，并且改写信号电压是，例如一个矩形脉冲电压，该电压在扫描周期中具有50%的占空比并且其正、负电压的绝对值彼此相同时，由于串扰施加给相应像素液晶的电压可以基本设为一个恒量，由此图象显示中由串扰产生的阴影能得到进一步的抑制。下面将对这个问题进行更详细的解释。

无论如何，信号电压的状态可以作如下调节：选择信号电压的施用周期为1/2扫描周期；改写信号电压在扫描周期中变化极性；扫描周期中改写信号电压的正、负电压有效值彼此基本相等；扫描周期内改写信号电压中每个正电压周期总数和负电压周期总数同选择信号电压的施用周期一样长。

施加到表现胆甾相的液晶上的电压可以通过调节信号电压的状态而变化，这样可以使液晶处于平面状态（选择性反射状态），焦锥状态（透明状态）或混合态（平面状态和焦锥状态相混合）。由此允许液晶显示器件进行选择性反射（彩色）显示，透明显示或一种中间态显示。

无论如何，通过连接一电源的扫描驱动集成电路可将驱动电压施加到扫描

电极上，该电源不仅能改变输出电压的正负，还能在每一帧中改变电源输出电压的正负。由此，在每一帧中施加到扫描电极的驱动电压可为单一极性，并且在每一帧中其极性可以翻转。这样,液晶器件的驱动可以通过简单的电路结构实现。

可将一电源提供给液晶设备和带有扫描驱动集成电路，信号驱动集成电路以及控制器的液晶显示器件驱动装置，该电源连接到扫描驱动集成电路并且能改变输出电压的正负，而通过连接到电源的扫描驱动集成电路，可以将驱动电压施加到扫描电极上。

在这种情况下，控制器可以控制电源和扫描驱动集成电路，使得电源输出电压在每一帧中由正变负或由负变正，由此施加到扫描电极上的驱动电压在各帧中为单一极性并且该极性在每一帧中进行翻转。

可如下所述地驱动液晶显示器件。在一个或多个电极的间隔扫描许多扫描电极，并以同样的方法扫描剩余的电极。当扫描在多个电极间隔进行时，依次重复循环，即可以实现一种交叉驱动。

在各帧中选中多个扫描电极并依次扫描,即可以进行渐进（非交叉）驱动。在将一帧分成多个段的交叉驱动情况下，各段中施加到扫描电极的选择信号电压的极性在每一段中可以发生翻转。

下面结合附图对液晶显示设备的实施例进行说明。

（液晶显示器件，见图1）

首先，说明包含有表现胆甾相（胆甾特性）液晶的液晶显示器件。

图1是可以用简单矩阵驱动方法驱动的反射/层压型全色液晶显示器件结构的截面图。

图1中的液晶显示器件100包括一个光吸收层121，一个铺在层121上的红色显示层111R，可以通过从红色选择性反射状态切换到透明状态来实现显示，反之亦然；一个铺在层111R上的绿色显示层111G，可以通过从绿色选择性反射状态切换到透明状态来实现显示，反之亦然；一个铺在层111G上的蓝色显示层111B，可以通过从蓝色选择性反射状态切换到透明状态来实现显示，反之亦然。

每个显示层111R,111G,111B包括树脂柱结构115，位于带有透明电极113，114的一对基板112之间的液晶116和隔离物117。需要的时候，在透明电极113、114

上形成绝缘膜118和定向控制膜119。

使用密封材料120在基板112之间的空间外周(显示区域之外)密封液晶116。

透明电极113、114分别连接到扫描驱动集成电路131和信号驱动集成电路132上（见图2），预定的脉冲电压分别施加到透明电极113、114上。响应于所加电压，液晶116的显示在允许可见光通过的透明状态和选择性反射特定波长的可见光的选择性反射状态之间切换。

分别形成在显示层111R，111G，111B上的透明电极113是许多相互之间隔有狭小空隙且互相平行延伸的条状电极。分别形成在显示层111R，111G，111B上的透明电极114也是许多相互之间隔有狭小空隙且互相平行延伸的条状电极。

当从一平面观察时，透明电极113、114是在相互间呈一直角方向相互对置的。电压依次施加到上部和下部条状电极上。即电压依次施加到矩阵方式的液晶116上以显示图象。这种方法称为矩阵驱动。每一个像素对应于电极113和电极114相互交叉的部位。将这样的矩阵驱动引入每一个显示层，由此可以在液晶显示器件100上显示出全色图象。

一般来说，在两基板间带有表现胆甾相的液晶的液晶显示器件中，将液晶在平面状态和焦锥状态间切换以显示图象。当液晶在平面状态时，选择性反射波长$\lambda = P \cdot n$（其中P是胆甾液晶的螺距，n是液晶的平均折射指标）的光。当液晶在焦锥状态时，在胆甾液晶的选择性反射波长处于红外光区域的情况下，散射入射到液晶上的光。当胆甾液晶的选择性反射波长较短时，光较少散射，大部分可见光可通过液晶。

因此，当选择性反射波长设定在可见光区域且在器件观察侧相反的一面上形成一光吸收层时，选择反射的颜色在平面状态时将显示出来，而在焦锥状态时会实现黑色的显示。

当选择性反射波长设定在红外光区域且在器件的观察侧相反的一面上形成一光吸收层时，由于在平面状态下反射处于红外光范围内波长的光而通过可见光范围内波长的光，因此可显示黑色。在焦锥状态下由于光的散射，可显示白光。

在带有相互叠放在一起的显示层111R，111G，111B的液晶显示器件中，当蓝色显示层111B和绿色显示层111G进入透明状态，其中的液晶分子处于焦锥排列,且红色显示层111R进入选择性反射状态，其中的液晶分子处于平面排列时，

可以实现红色显示。蓝色显示层111B进入透明状态，其中的液晶分子处于焦锥排列，且绿色显示层111G和红色显示层111R进入选择性反射状态，其中的液晶分子处于平面排列，由此可以实现黄色显示。类似的，适宜地将透明状态或选择性反射状态选为各个显示层的状态，由此可以显示出红、绿、蓝、白、青、紫、黄或黑色。

此外,当将一中间选择性反射状态选为显示层111R、111G、111B的状态时，可以显示出过渡色并利用其实现全色显示。

在室温下表现出胆甾相（胆甾特征）的液晶可以优先用作液晶116。特别适于使用一种手征性向列液晶，它是通过向向列液晶中加入足够量的手征性材料以呈现胆甾相制备得到的。

手征性材料是一种添加剂,当加入到向列液晶中时能使向列液晶分子扭曲。通过向向列液晶中添加手征性材料，赋予向列液晶一种液晶扭曲分子的螺旋状构造, 由此使其呈胆甾相。

液晶显示层的结构不必受上面描述的限制。壁状或类似的树脂结构可以用来代替柱状结构115,或省去这样的树脂结构。液晶层的可用结构包括常用结构，如一种液晶散布在三维聚合物网络中的层状结构，一种由液晶组成的三维聚合物网络（所谓分散聚合物型液晶化合物膜）的层状结构等。

（驱动电路，见图2和3）

图2是一例驱动电路的框图，它是向液晶层施加驱动电压的驱动装置主要部分。图3是图2中驱动电路的具体结构的例子。图3中的逻辑电源和逻辑电平变换器在图2中省略了。

液晶显示设备包括图2和图3中的液晶显示器件100和驱动装置。

根据图示中的液晶显示设备，根据包含在后面要介绍的控制器CONT中的图象存储器138所存储的图象数据，驱动集成电路131、132由LCD控制器136控制。在液晶显示器件100中的扫描电极和信号电极之间依次施加电压，由此将图象写入到液晶显示器件100中。

下面要说明的图2、3和图4、5表示了在红、绿、蓝任一显示层中的驱动集成电路131、132。更明确地讲，实际上在红、绿、蓝每一显示层中都配有驱动集成电路131、132。最好给红、绿、蓝每一显示层都配备驱动集成电路131、132（即分别在三种层中配备集成电路）。在这三层共享时，可以使用任一驱动集成

电路131、132。

图2和3中的驱动装置包括扫描驱动集成电路（驱动器）131，信号驱动集成电路（驱动器）132，控制器CONT和电源140。

控制器CONT配有适于整体控制驱动装置的中央处理单元（CPU）135，适于控制驱动集成电路的LCD控制器136，用各种方式处理图象数据的图象处理单元137,以及存储图象数据的图象存储器138。从电源140向控制器CONT提供电源。控制器CONT连接信号驱动集成电路132，并通过逻辑电平转换器连接扫描驱动集成电路131。逻辑电平转换器是适于将地（GND）电位变换到0V的电路，用于补偿如果地（GND）电位变得不为零的情况,尽管对应于施加到扫描驱动集成电路的电压，地（GND）保持在0V。LCD控制器136按照CPU135的指示根据存储在存储器138中的图象数据驱动各个驱动集成电路。

如图2所示，分布在液晶显示器件100上的像素由一个矩阵表示，该矩阵包括许多扫描电极113（图2中的R1、R2……Rm）和许多信号电极114（图2中的C1、C2……Cn）（“m”和“n”是自然数）。扫描电极R1、R2……Rm连接到扫描驱动集成电路131的输出端，而信号电极C1、C2……Cn连接到信号驱动集成电路132的输出端。

扫描驱动集成电路131如上所述连接到扫描电极R1、R2……Rm，还连接到控制器CONT和电源140。驱动集成电路131将一驱动电压施加到扫描电极R1、R2……Rm上，该电压包括一复位电压（+V1或—V1），一选择信号电压（+V2或—V2）以及一维持电压（+V3或—V3）。

复位电压输出是一个例如+40V的正复位脉冲+V1或—40V的负复位脉冲—V1。选择信号电压输出是一个例如+15V的正选择脉冲+V2或—15V的负选择脉冲—V2，而维持电压输出是一个例如+25V的正维持脉冲+V3或—25V的负维持脉冲—V3。这些电压由扫描驱动集成电路131输出。

对应于所述电压的接地（GND）的电压稳定电容器C连接到连接线上，向扫描电极113施加电压+V1、+V2和+V3，以及—V1、—V2和—V3。连接到扫描驱动集成电路131的逻辑电源用于向扫描驱动集成电路131提供电源。

信号驱动集成电路132如上所述连接到信号电极C1、C2……Cn上，还连接到控制器CONT和电源140上。根据来自控制器CONT的指示，从电源140输出的电压（改写信号电压（+V4、—V4））分别施加到信号电极C1、C2……Cn上。

改写信号电压是由信号驱动集成电路132输出的+3V的正信号脉冲+V4和−3V的负信号脉冲−V4。

对应于所述电压的接地（GND）的电压稳定电容器C连接到连接线上，向信号电极施加驱动电压（+V4、-V4）。

更具体的情况下，扫描驱动集成电路131输出选择信号电压到扫描电极R1、R2……Rm中的一个预定电极，使其进入选择状态，同时根据来自控制器CONT的指示向其它电极输出非选择信号以使它们进入非选择状态。当切换电极时，扫描驱动集成电路131依次将选择信号电压施加到扫描电极R1、R2……Rm上。在为扫描电极设置的一个扫描周期中，将选择信号电压施加到一个扫描电极上。

另一方面，根据来自控制器CONT的指示，信号驱动集成电路132同时将对应于图象数据的信号（改写信号电压）输出到信号电极C1、C2……Cn上，以改写处于选择状态下的扫描电极上的每个像素。例如，如果选中了扫描电极Ra（Ra中的“a”是满足“a”≦m的自然数），将同时改写对应于扫描电极Ra和信号电极C1、C2……Cn间交叉点的像素LRa−C1……LRa−Cn。在每个像素中，施加到扫描电极的选择脉冲电压（选择信号电压）和施加到信号电极的信号脉冲电压（改写信号电压）之间的电压差是用于改写像素的电压，根据这个电压改写像素。

控制器CONT用于控制扫描驱动集成电路131，这样在用于液晶显示器件100矩阵驱动的每一帧的扫描操作中，施加到扫描电极R1、R2……Rm上的驱动电压在各帧中具有单一极性，并且在每一帧中驱动电压的极性翻转。

更具体的情况下，当在奇数帧中扫描时，扫描驱动集成电路131依次向每个扫描电极R1、R2……Rm施加正复位脉冲电压+V1，正选择脉冲电压+V2和正维持脉冲电压+V3，同时信号驱动集成电路132向每个信号电极C1、C2……Cn施加信号脉冲±V4。

当在偶数帧中扫描时，扫描驱动集成电路131依次向每个扫描电极R1、R2……Rm施加负复位脉冲电压−V1，负选择脉冲电压−V2和负维持脉冲电压−V3，同时信号驱动集成电路132向每个信号电极C1、C2……Cn施加信号脉冲±V4（见图6−8）。

在前述操作中，选择脉冲电压（选择信号电压）（+V2或−V2）的施用周

期Tsp是1/2扫描周期Tss，信号脉冲±V4为在扫描周期Tss内变化极性的电压，并且在扫描周期Tss中上述正、负电压的有效值彼此基本相等。

此外，信号脉冲为扫描周期Tss中每个正电压周期总数和负电压周期总数都和选择脉冲的施用周期Tsp一样长。

如上所述,控制器CONT控制扫描驱动集成电路131使选择脉冲（＋V2或－V2）的施用周期Tsp为1/2扫描周期Tss，并且控制信号驱动集成电路132使信号脉冲±V4为在扫描周期Tss内变化极性的电压；在扫描周期Tss中信号脉冲正、负电压的有效值彼此基本相等；并且信号脉冲为扫描周期中每个正电压周期总数和负电压周期总数都和选择脉冲（＋V2、－V2）的施用周期一样长。有关驱动原理和基本驱动实例还会进行更详细的说明。

信号脉冲电压±V4是占空比为50%的矩形脉冲电压，而且正、负电压（＋V4、－V4）的绝对值是彼此相同的。

在该驱动装置中，电源140至少可以在驱动操作的整个周期内提供正电压和负电压。驱动电压由连接到电源140的扫描驱动集成电路施加给扫描电极R1、R2……Rm。

但电源的提供不受上面内容的限制。驱动电压可以由连接到电源的扫描驱动集成电路施加给扫描电极R1、R2……Rm,所述电源可以将电压输出从正变为负，反之亦然。

图4和图5是驱动电路结构的另一个例子。在图4和图5的电路结构中，在图3所示的电路结构中电源140和扫描驱动集成电路之间提供了一个电源切换电路141。

在图4和5的电路结构中，电源140和电源切换电路141组成了一个可以切换正负输出电压的电源140′。

电源140′连接到控制器CONT，并具有4个开关部件SW1至SW4。

部件SW1至SW4可以在来自控制器CONT的指示下同时切换到施加正驱动电压的状态（图中1侧）或施加负驱动电压的状态（图中2侧）。当开关部件处于1侧状态时,电源140′可以从电源140向扫描驱动集成电路131提供正电压＋V1、＋V2、＋V3。另一方面，当开关部件处于2侧状态时，电源140′可以从电源140向扫描驱动集成电路131提供负电压－V1、－V2、－V3。

在具有图4和5所示电路结构的驱动装置中，控制器CONT可以控制电源140′

和扫描驱动集成电路131，通过从正电压+V1、+V2、+V3变换到负电压−V1、−V2、−V3或反向变换，使得要施加到扫描电极113上的驱动电压在各帧中具有单一极性，且在每一帧中有效实现极性的翻转。根据该驱动装置，可以通过简单电路结构实现液晶显示器件的驱动。图4是开关部件SW1至SW4切换到1侧时的奇数帧（正帧）状态。图5是开关部件SW1至SW4切换到2侧时的偶数帧（负帧）状态。

一般通过依次选择所有的扫描线改写图象。当部分改写图象时，以某种程度单独依次地选中特定扫描线以包括要改写的部分。这样在较短的时间内可以仅改写需要的部分。在图4和5所示的电路结构中，提供给扫描驱动集成电路的电压为图3结构中电压的1/2。因此与图3结构相比，可以使用更廉价和具有相对低的电压阻抗的扫描驱动集成电路。

（驱动原理和基本驱动例子，见图6至11）

首先对液晶显示器件100的驱动方法的基本原理进行说明。以下，将参考使用脉冲波形的具体例子对这个问题进行说明。但是,驱动方法不限于这些波形。

图6（A）是在奇数帧（正帧）中从扫描驱动集成电路131输出到每个扫描电极的基本驱动波形的例子，图6（B）是偶数帧（负帧）中从扫描驱动集成电路131输出到每个扫描电极的基本驱动波形的例子。

图7和8是从扫描驱动集成电路131输出到每个扫描电极113（行电极）的电压波形，从信号驱动集成电路132输出到一个信号电极（列电极）的电压波形，以及由这些电压施加给相应像素的液晶（如图中LCD1至LCD2所示）的电压波形。图7是奇数帧中的电压波形，图8是偶数帧中的电压波形。

图7和8表示一个基本驱动的例子，其中选择脉冲电压（选择信号电压）依次输出给许多扫描电极113（如图中28条行电极1、2−28），一信号脉冲（改写信号电压）从许多信号电极114（许多列电极）中的一个信号电极（在图中示为一列b，“b”是满足b≤n的自然数）输出。

图中从列b输出的信号脉冲波形是在任一扫描周期Tss中可以依次输出选择液晶选择性反射状态的一个脉冲的波形。可以从列b中输出选择透明状态的信号脉冲波形，选择一选择性反射状态的信号脉冲波形以及选择混合状态（上述状态的混合）的信号脉冲波形中的任一种波形。这个问题将在下面作更详细的描述。

在图中LCD1、2至28表示的是由扫描电极(行1、2至28)和信号电极（列b）间交叉点形成的相应像素的液晶，和施加到相应像素液晶上的电压波形。由于施加到信号电极的信号脉冲产生的串扰脉冲将施加到液晶上。图7和8中的粗线表示施加串扰脉冲的范围。下面将详细解释这个问题。

在这种驱动中，如上所述，扫描中要施加到扫描电极（行1、2至28）的驱动电压在各个帧中为单一极性且在每一帧中极性翻转。例如，在扫描一帧中驱动电压保持单一极性，即使用第一扫描电极（行1）至最后一个扫描电极(行28),直到完成这一帧的扫描操作。然后翻转驱动电压的极性以在下一帧中扫描。

一个驱动周期大致分为复位周期Trs，选择周期Ts，维持周期Trt和显示周期Ti。选择周期Ts细分为选择脉冲施用周期（选择信号电压施用周期）Tsp，预选择周期Tsz和过选择周期Tsz’。复位周期Trs和维持周期Trt为，例如48ms。选择周期Ts为，例如0.6ms。预选择周期Tsz和过选择周期Tsz’同为，例如选择周期Ts(0.6ms)的 1/3（0.2ms）。扫描周期Tss是选择周期Ts(0.6ms）的1/3（0.2ms）。如上所述，选择脉冲施用周期Tsp是扫描周期Tss的1/2 （0.1ms）。

如图6至8所示，在基本驱动波形中，在复位周期Trs中施加复位脉冲（在奇数帧中的正脉冲＋V1,在偶数帧中的负脉冲－V1）。选择周期Ts中，在选择脉冲施用周期Tsp内施加选择脉冲（在奇数帧中的正脉冲＋V2,在偶数帧中的负脉冲－V2）。在包含周期Tsp的扫描周期Tss中,从信号驱动集成电路132施加信号脉冲±V4。信号脉冲±V4由图象数据决定。如上所述，信号脉冲±V4是占空比为50%的矩形脉冲，而且其中正、负电压（＋V4、－V4）的绝对值是彼此相同的。在基本驱动波形中，电压在预选择周期Tsz和过选择周期Tsz’中为零。此外，在维持周期Trt中施加维持脉冲（在奇数帧中的正脉冲＋V3,在偶数帧中的负脉冲－V3）。

液晶操作如下。首先，当在复位周期Trs中施加复位脉冲＋V1（奇数帧）或－V1（偶数帧）时，液晶回复到初始状态。复位周期Trs经过预选择周期Tsz(液晶在这期间轻微反扭曲）进入到选择脉冲施用周期Tsp。在周期Tsp中要施加到液晶的脉冲波形随最终选择为平面状态的像素或最终选择为焦锥状态的像素而发生改变。

图6至8是选择平面状态的情况。当选择焦锥状态时，与选择平面状态时相比，信号脉冲的位相变换为对应于半周期的程度。

下面将解释选择平面状态的情况。这时，在选择脉冲施用周期Tsp中，在奇数帧中的电压[(+V2)-(-V4)]或偶数帧中的电压[(一V2)-(+V4)]施加到液晶上，以使液晶再次进入初始状态。其后，在过选择周期Tsz'中液晶变得轻微反扭曲(retwist)。然后当在维持周期Trt中施加+V3（奇数帧）或一V3（偶数帧）的维持脉冲时，在过选择周期Tsz'中已经轻微反扭曲的液晶通过施加维持脉冲变得更松弛并进入初始状态。

在初始状态的液晶通过变换到零电压进入平面状态并固定在平面状态中。

另一方面，当最终选择焦锥状态时，在选择脉冲施用周期Tsp中，施加奇数帧中的电压[(+V2)-(+V4)]或偶数帧中的电压[(一V2)-(一V4)]。在过选择周期Tsz'中，液晶变得反扭曲并变为螺距扩展为大约两倍的状态。

随后，在维持周期Trt中施加+V3（奇数帧）或一V3（偶数帧）的维持脉冲。在过选择周期Tsz'中已经轻微反扭曲的液晶通过施加维持脉冲进入焦锥状态。在焦锥状态的液晶通过变换到零电压而固定在焦锥状态。

根据上面所述的方法和液晶显示设备以及驱动液晶显示器件的装置，当在液晶显示器件100矩阵驱动的每一帧中执行扫描操作时，要施加到扫描电极113上的驱动电压在各个帧中保持单一极性，并且在每一帧中极性翻转，由此在各帧中施加到液晶116上的电压的单一极性状态可以连续维持一个很长的时间周期。因此与使用，例如施加到液晶116上的电压波形极性周期性变化的交变电压相比，可以将施加到液晶116上电压的波形重复频率减小，并且施加到扫描电极113上的驱动电压值可以减为1/2，由此相应地降低驱动液晶显示器件100的能耗。即能用更少的能耗驱动液晶显示器件100。

如上所述，液晶的最终显示状态可以通过在选择脉冲施用周期Tsp中施加到液晶上的脉冲来选择。通过调节脉冲电压值，脉宽和/或相位，更具体的说是根据图象数据调节施加到信号电极上的脉冲信号波形，可以获得中间态显示。

下面将对通过改变施加给信号电极的信号脉冲状态来实现中间态显示进行说明。

图9至11是输出到从行1至28中选出的一信号行a上的选择脉冲电压的波形，输出到列b的信号脉冲电压波形以及奇数帧（正帧）中由选择脉冲电压和信号脉冲电压施加到液晶LCDx上的电压波形。

图9表示将液晶最终设为最大选择性反射状态的波形。图10表示将液晶最终

设为中间态显示状态的波形。图11为将液晶最终设为透明状态的波形。

图12（A）、图12（B）和图12（C）为输出到行a的选择脉冲电压波形，输出到列b的信号脉冲电压波形以及施加到液晶LCDx上的电压波形，它们主要处于选择周期中，这些视图分别从图10、图9和图11所示波形中放大了。

如图12（A）至图12（C）所示，施加到列b的信号脉冲±V4在信号脉冲施用周期Tw（扫描周期Tss）中信号脉冲电压的负周期总数（或正周期总数）同在选择脉冲施用周期Tsp一样长。因此，可以在一个周期中从零到Tsp(1/2扫描周期Tss)地变换与施用到行a的选择脉冲同步施加到列b上的信号脉冲的上升时刻或下降时刻（见图12（A）中t1（或t2）），从而改变选择脉冲施用周期中施加到液晶LCDx的每个脉冲电压的最高部分|V2+V4|和最低部分|V2－V4|的宽度，并控制液晶的最终状态。

如图12（A）所示，在选择液晶中间态显示状态的电压波形中，选择脉冲施用周期中施加到液晶LCDx上的脉冲电压的最高部分|V2+V4|和最低部分|V2－V4|的施用周期总数等于选择脉冲施用周期Tsp。如图12(B)所示，在选择液晶选择性反射状态的电压波形中，在选择脉冲施用周期中施加到液晶LCDx的脉冲电压最高部分|V2+V4|的宽度等于选择脉冲施用周期Tsp的宽度。如图12(C)所示，在选择液晶透明状态的电压波形中，在选择脉冲施用周期中施加到液晶LCDx的脉冲电压最低部分|V2－V4|的宽度等于选择脉冲施用周期Tsp的宽度。

除了施加到行的电压极性和施加到列上的电压极性进行了翻转以外，在各行施加负电压的负帧操作同正帧是相同的。

如图7和8中粗线所示，由于施加到信号电极上的信号脉冲，任一施加到液晶LCD1、LCD2上的电压波形都会发生串扰。

但是，施加到列b上的信号脉冲波形是占空比为50%的矩形脉冲波形，而且其正、负电压的绝对值是彼此相同的。分别如图12（A）至图12（C）所示，在任一选择液晶显示状态的波形中，由于在复位周期中有效电压是$\sqrt{\{[(V1+V4)^2+(V1-V4)^2]/2\}}$，在维持周期中有效电压是$\sqrt{\{[(V3+V4)^2+(V3-V4)^2]/2\}}$，所以在复位周期施加到液晶上的电压和在维持周期施加到液晶的电压是恒定的。

如上所述，如果施加到行a上的选择脉冲电压是一个施用周期Tsp为1/2扫描周期Tss的电压，并且施加到列b上的信号脉冲电压具有矩形脉冲波形，该波形的

占空比为50%，而且其中正、负电压的绝对值彼此相同，由于串扰，施加到相应于像素的液晶LCD1、LCD2至LCD28上的电压可以设为基本恒定，由此可以抑制由于串扰在图象显示中阴影的产生。

上述实施例使用的信号脉冲的占空比为50%，而且其中正或负的持续时间和Tsp一样长。但是，如果占空比为50%，没有正或负持续时间与Tsp一样长的特性，仍然可以获得抑制阴影的效果。那样的话，当维持50%的占空比50%时，信号脉冲可以分成两部分输出。

但是，这种情况下造成了两倍的信号脉冲翻转频率和由信号脉冲引起的两倍的显示器件（显示屏）能耗。图13（A）至图13(C)是一个信号脉冲的例子，其中正或负电压的持续时间T1或T2与选择信号施用周期Tsp不一样长。在该例中，可以通过施加如图13(A)所示的信号脉冲来选择中间态显示状态，其中持续时间T1和T2的总和保持为周期Tsp。通过改变持续时间T1和T2的比率并保持时间T1和T2的总和为周期Tsp，可以选择包括最大选择性反射显示状态（平面状态：T1=0,T2=Tsp:图13（B））和透明状态（焦锥状态：T1=Tsp,T2=0:图13（C））的各态的显示状态。

虽然对本发明进行了详细的说明和举例，可以清楚地理解，这些都只是对本发明的解释和举例，并不是对本发明的限制，本发明的要旨和范围仅由所附权利要求的各项限定。

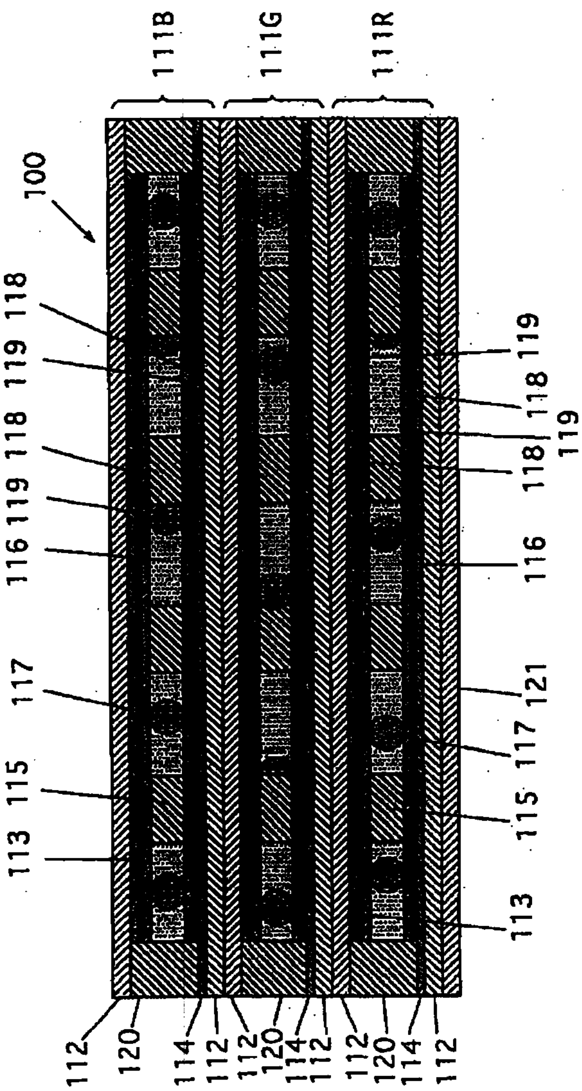

111B
111G
111R
100
118
119
118
119
116
117
115
113
119
118
119
118
116
121
117
115
113
112
120
114
112
112
120
114
112
112
120
114
112

图 1

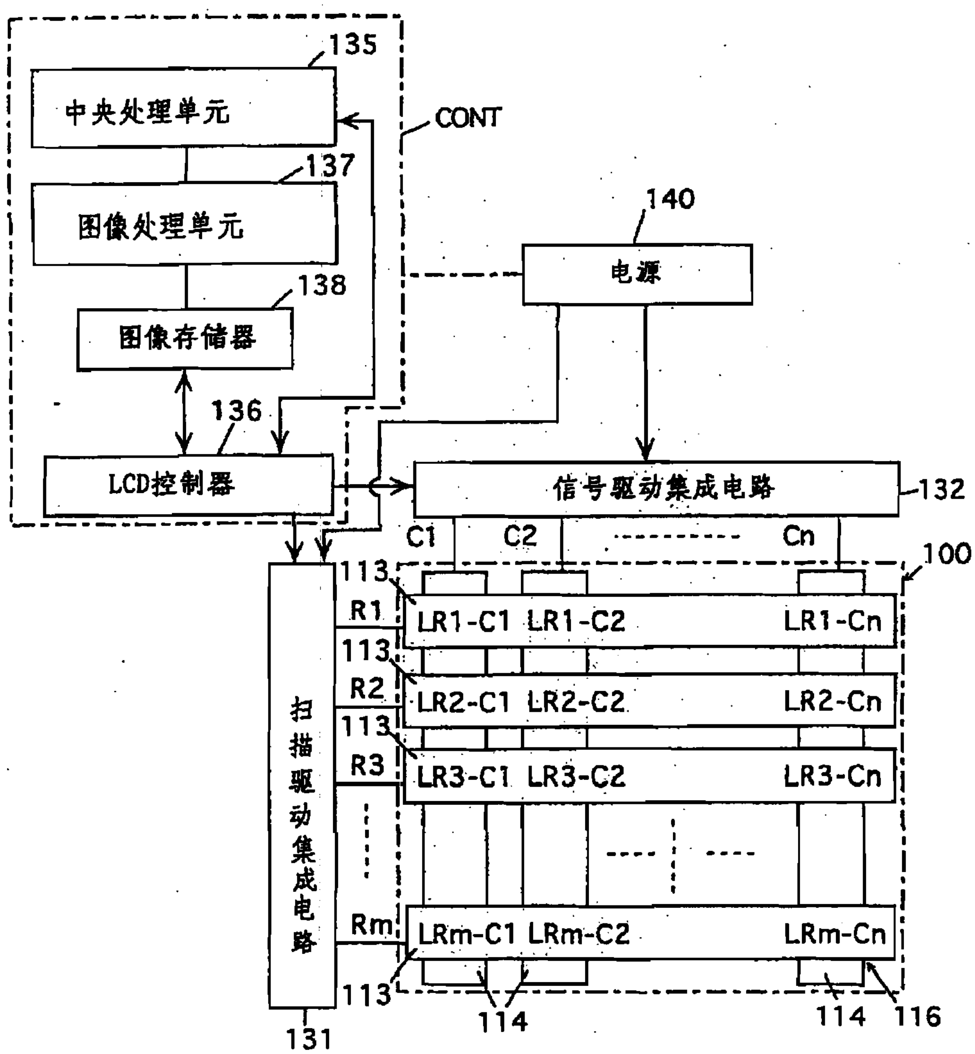

135
中央处理单元
CONT
137
图像处理单元
138
图像存储器
136
LCD控制器
140
电源
信号驱动集成电路
132
C1
C2
Cn
100
113
R1
LR1-C1 LR1-C2
LR1-Cn
113
R2
LR2-C1 LR2-C2
LR2-Cn
113
R3
LR3-C1 LR3-C2
LR3-Cn
扫描驱动集成电路
Rm
LRm-C1 LRm-C2
LRm-Cn
113
114
114
116
131

图 2

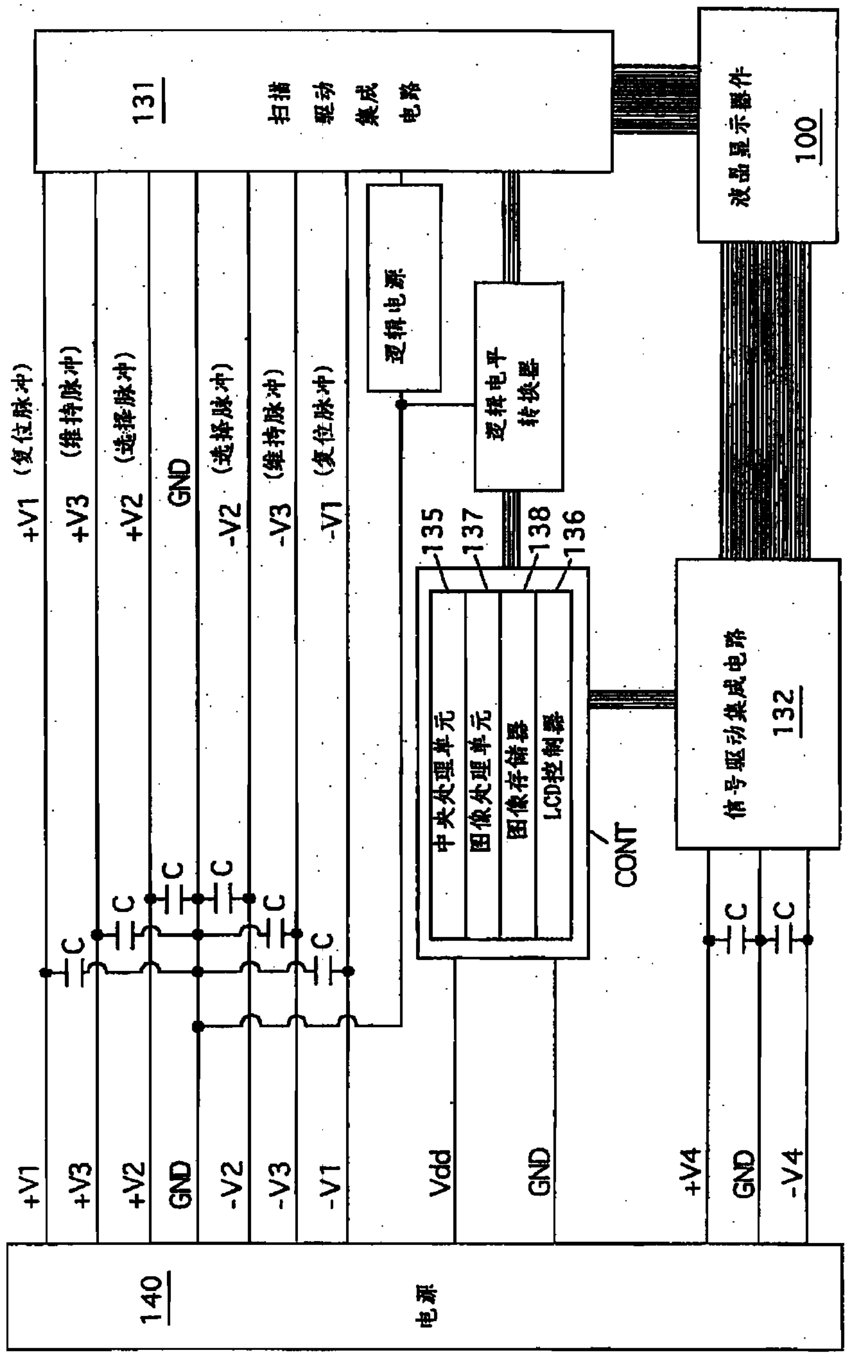

131
扫描驱动集成电路
液晶显示器件
100
逻辑电源
逻辑电平转换器
+V1 (复位脉冲)
+V3 (维持脉冲)
+V2 (选择脉冲)
GND
-V2 (选择脉冲)
-V3 (维持脉冲)
-V1 (复位脉冲)
135
137
138
136
中央处理单元
图像处理单元
图像存储器
LCD控制器
CONT
信号驱动集成电路
132
C
+V1
+V3
+V2
GND
-V2
-V3
-V1
Vdd
GND
+V4
GND
-V4
140
电源

图 3

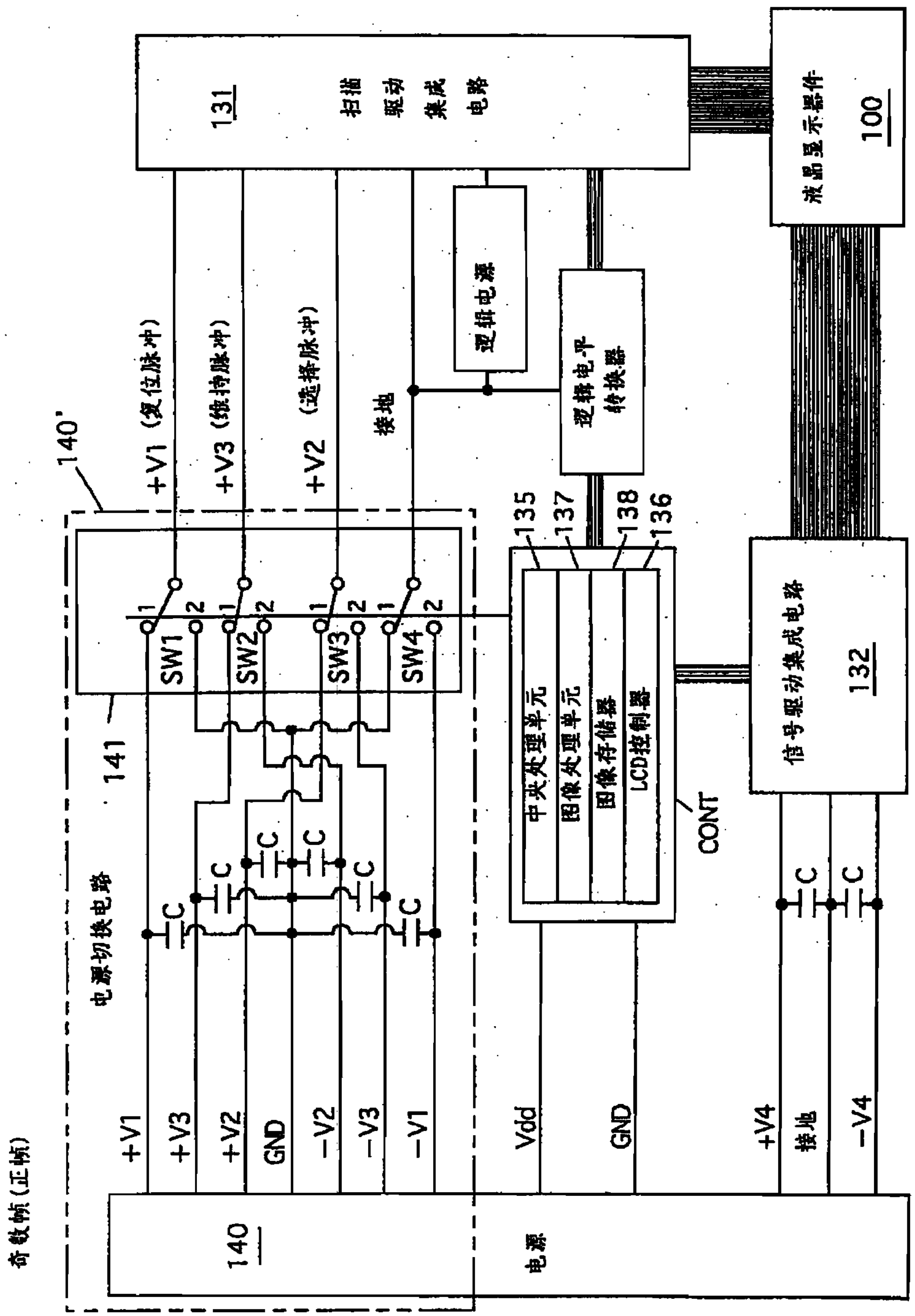

131
扫描驱动集成电路
100
液晶显示器件
逻辑电源
逻辑电平转换器
140'
+V1 (复位脉冲)
+V3 (维持脉冲)
+V2 (选择脉冲)
接地
SW1
SW2
SW3
SW4
141
电源切换电路
C
+V1
+V3
+V2
GND
−V2
−V3
−V1
135
137
138
136
中央处理单元
图像处理单元
图像存储器
LCD控制器
CONT
132
信号驱动集成电路
Vdd
GND
+V4
接地
−V4
140
电源
奇数帧(正帧)

图 4

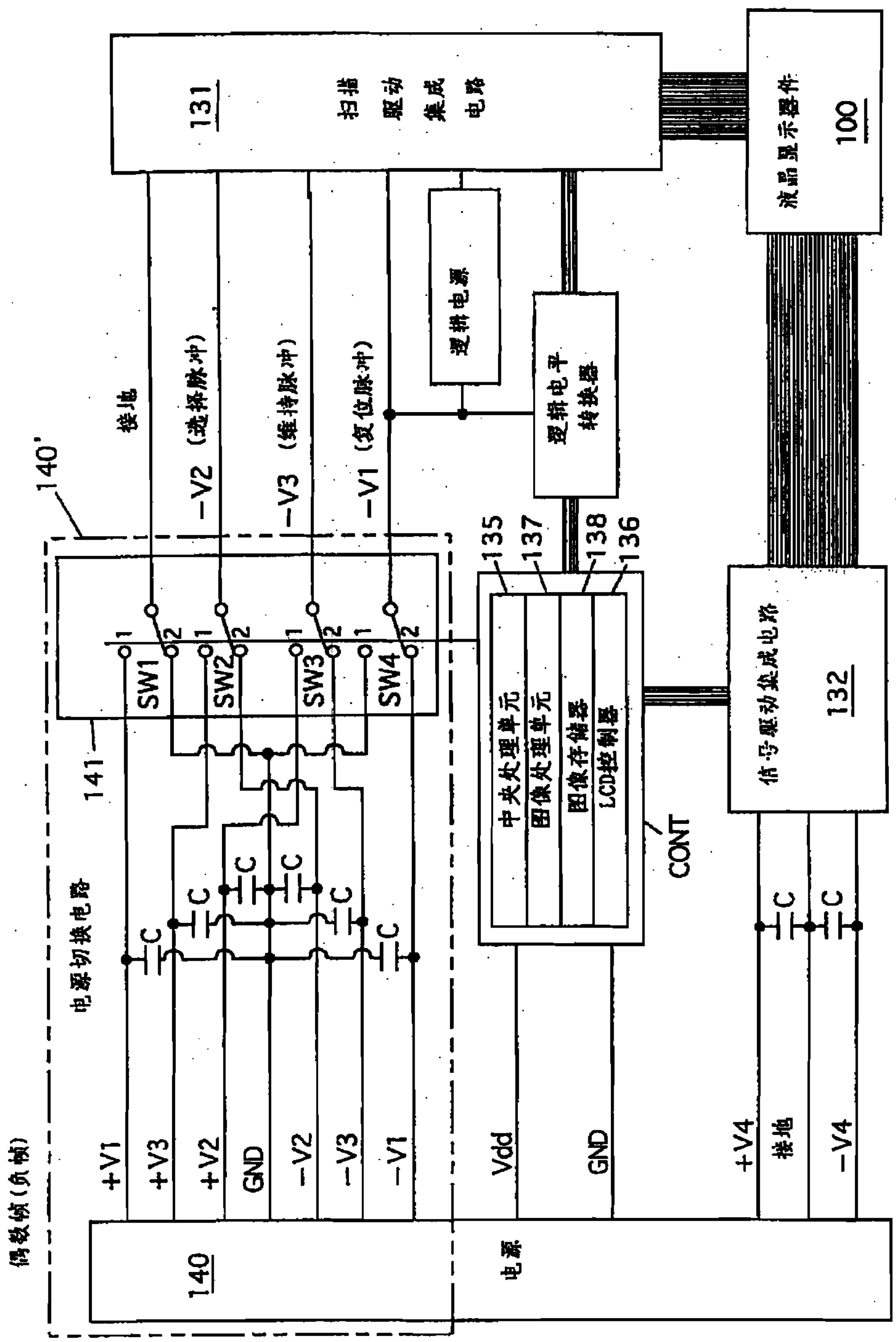
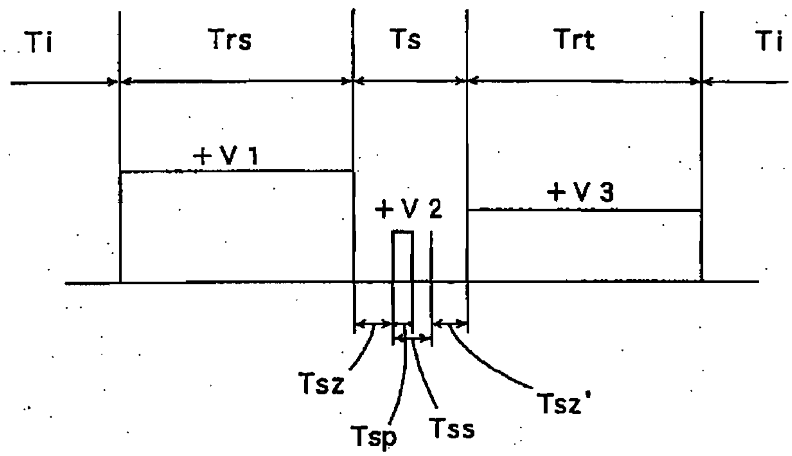

131
扫描驱动集成电路
液晶显示器件
100
逻辑电源
逻辑电平转换器
接地
−V2（选择脉冲）
−V3（维持脉冲）
−V1（复位脉冲）
140'
SW1
SW2
SW3
SW4
141
C
135
137
138
136
中央处理单元
图像处理单元
图像存储器
LCD控制器
CONT
信号驱动集成电路
132
电源切换电路
偶数帧（负帧）
+V1
+V3
+V2
GND
−V2
−V3
−V1
Vdd
GND
+V4
接地
−V4
140
电源

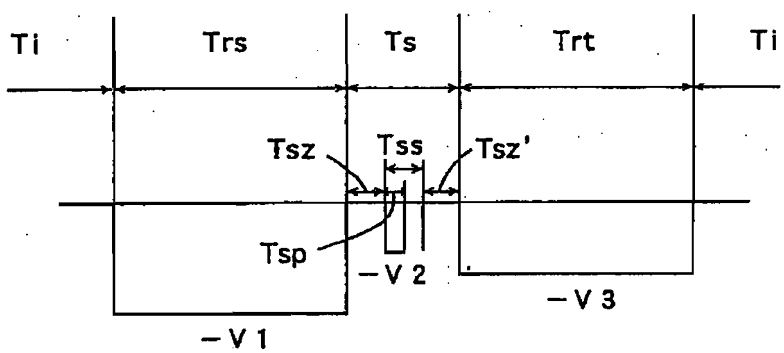
图 5



Ti: 显示周期
Trs: 复位周期
Ts: 选择周期
Trt: 维持周期
Tsz: 预选择周期

Tsz' : 过选择周期
Tss: 扫描周期
Tsp: 选择脉冲施用周期
+V1: 复位脉冲电压
+V2: 选择脉冲电压
+V3: 维持脉冲电压

图 6(A)



-V1: 复位脉冲电压
-V2: 选择脉冲电压
-V3: 维持脉冲电压

图 6(B)

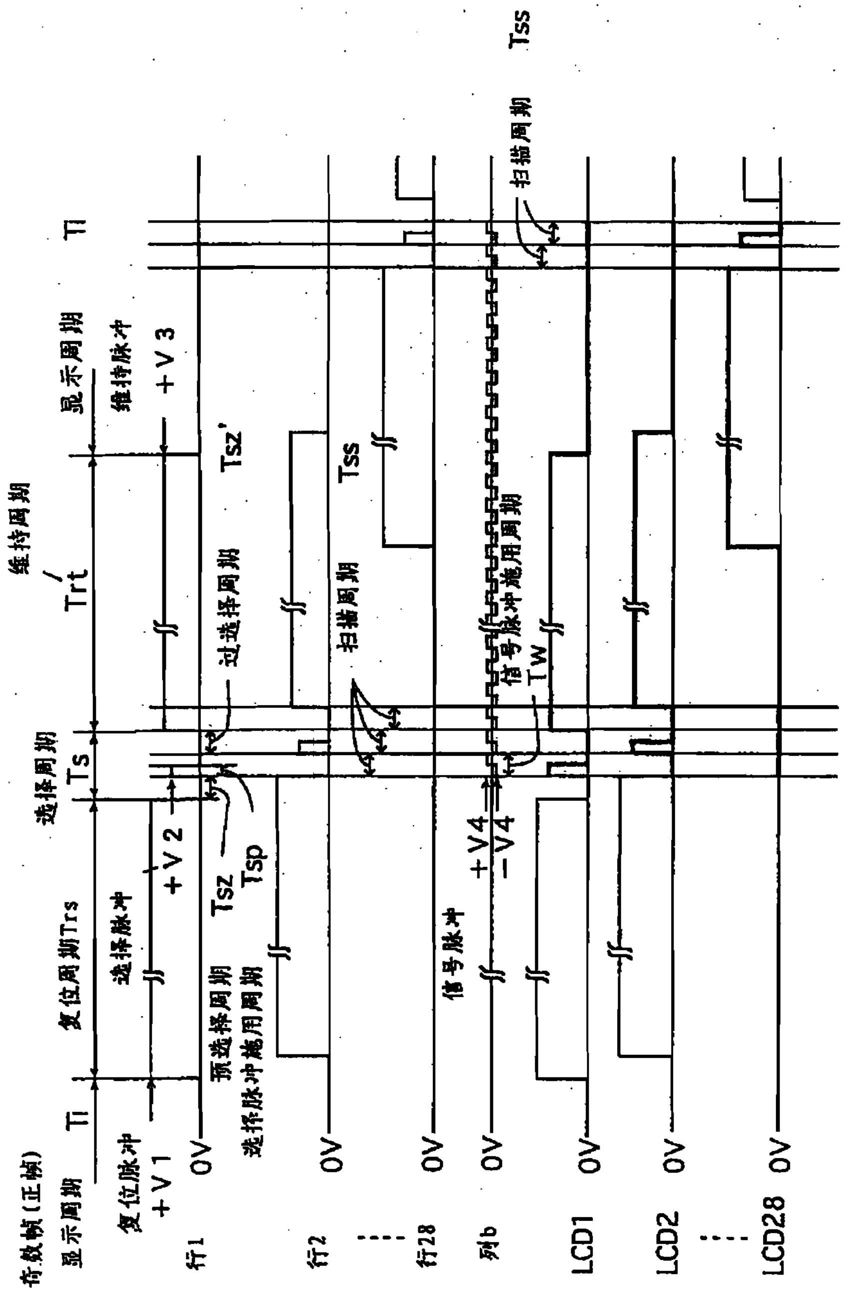

奇数帧(正帧)
显示周期
Tl
复位周期Trs
选择周期
Ts
维持周期
Trt
显示周期
Tl
复位脉冲
+V1
选择脉冲
+V2
维持脉冲
+V3
行1
0V
预选择周期
选择脉冲施用周期
Tsz
Tsp
过选择周期
Tsz'
行2
扫描周期
Tss
行28
列b
信号脉冲
+V4
−V4
信号脉冲施用周期
TW
扫描周期
Tss
LCD1
LCD2
LCD28

图 7

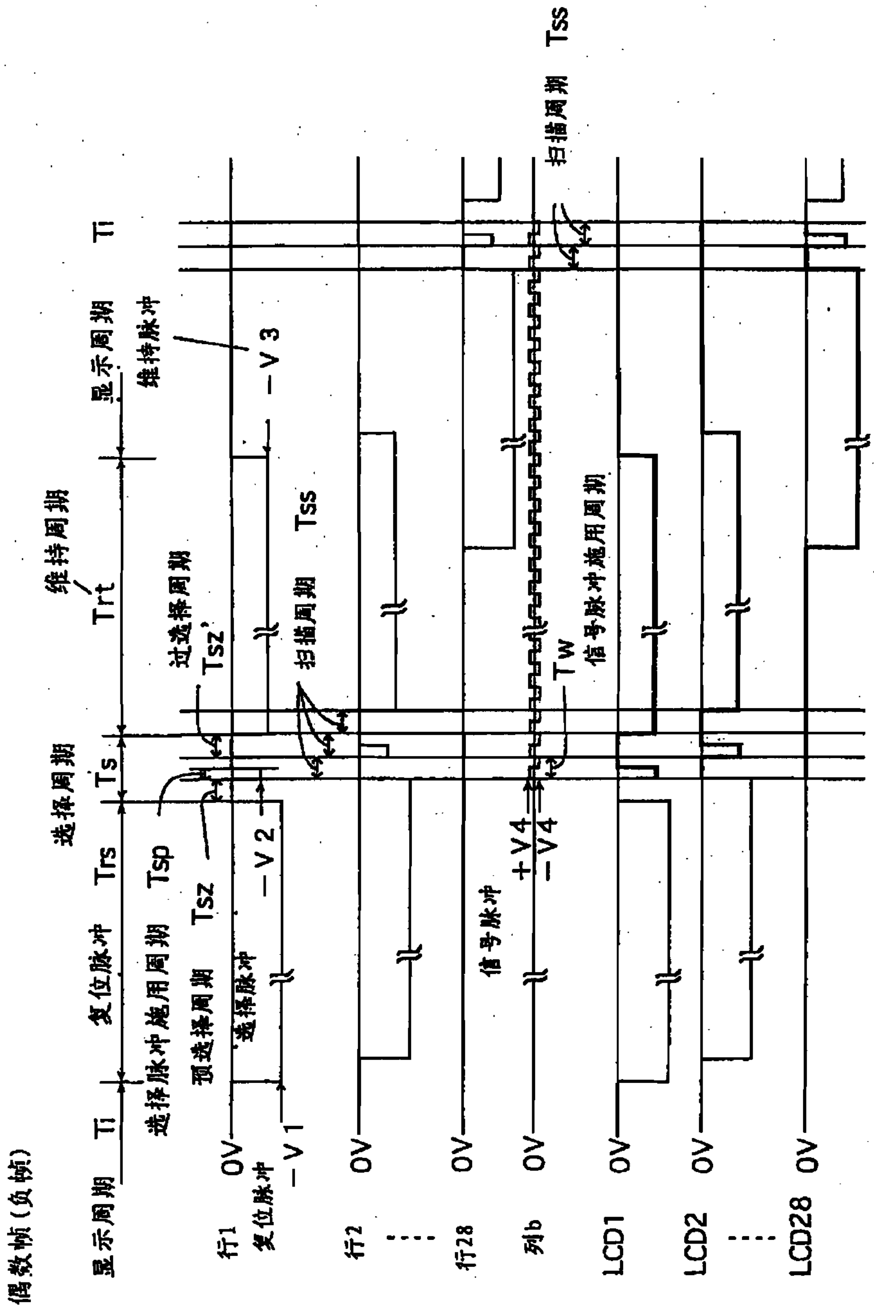

偶数帧(负帧)
显示周期
Ti
复位脉冲
Trs
选择周期
Ts
维持周期
Trt
显示周期
Ti
选择脉冲施用周期
预选择周期
Tsz
Tsp
过选择周期
Tsz'
扫描周期
Tss
维持脉冲
−V3
−V2
−V1
选择脉冲
复位脉冲
行1
行2
行28
列b
LCD1
LCD2
LCD28
0V
信号脉冲
+V4
−V4
Tw
信号脉冲施用周期
扫描周期
Tss

图 8

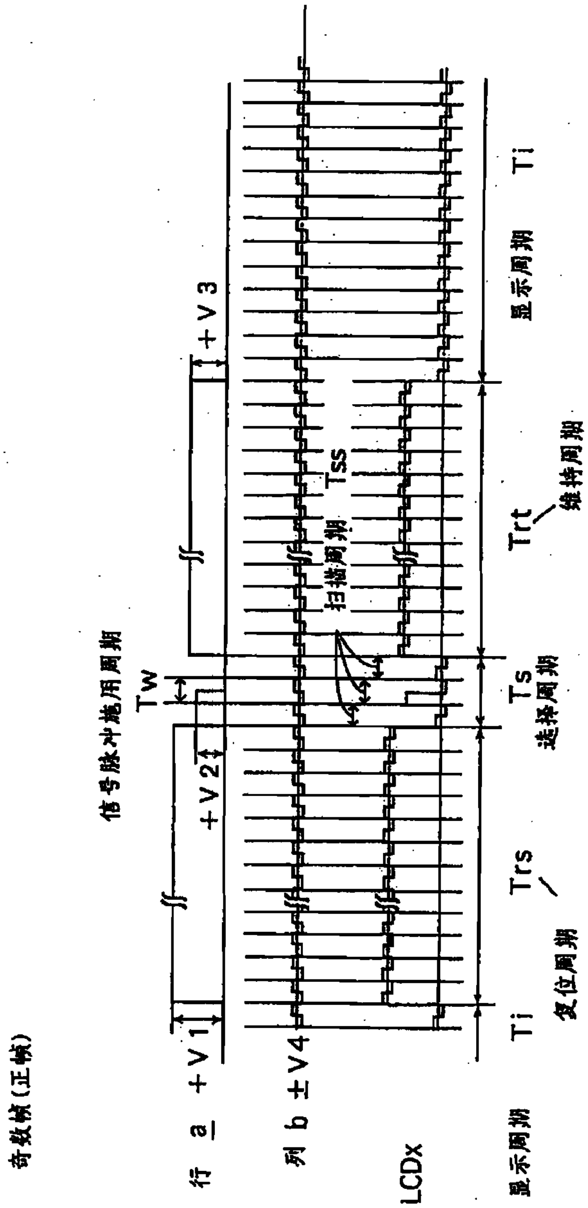

奇数帧(正帧)
行 a
+V1
列 b ±V4
LCDx
显示周期
Ti
复位周期
Trs
+V2
信号脉冲施用周期
Tw
选择周期
Ts
扫描周期
Tss
Trt
维持周期
+V3
显示周期
Ti

图 9

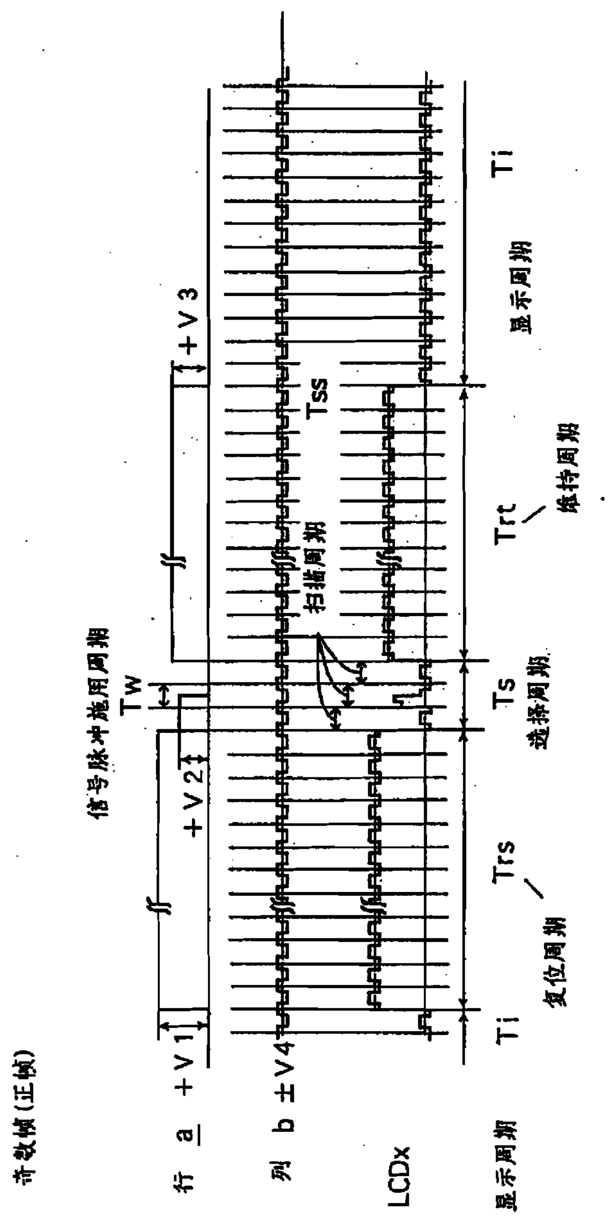

奇数帧(正帧)
行 a +V1
+V2
信号脉冲施用周期
Tw
+V3
列 b ±V4
扫描周期
Tss
LCDx
显示周期
Ti
Trs
复位周期
Ts
选择周期
Trt
维持周期
显示周期
Ti

图 10

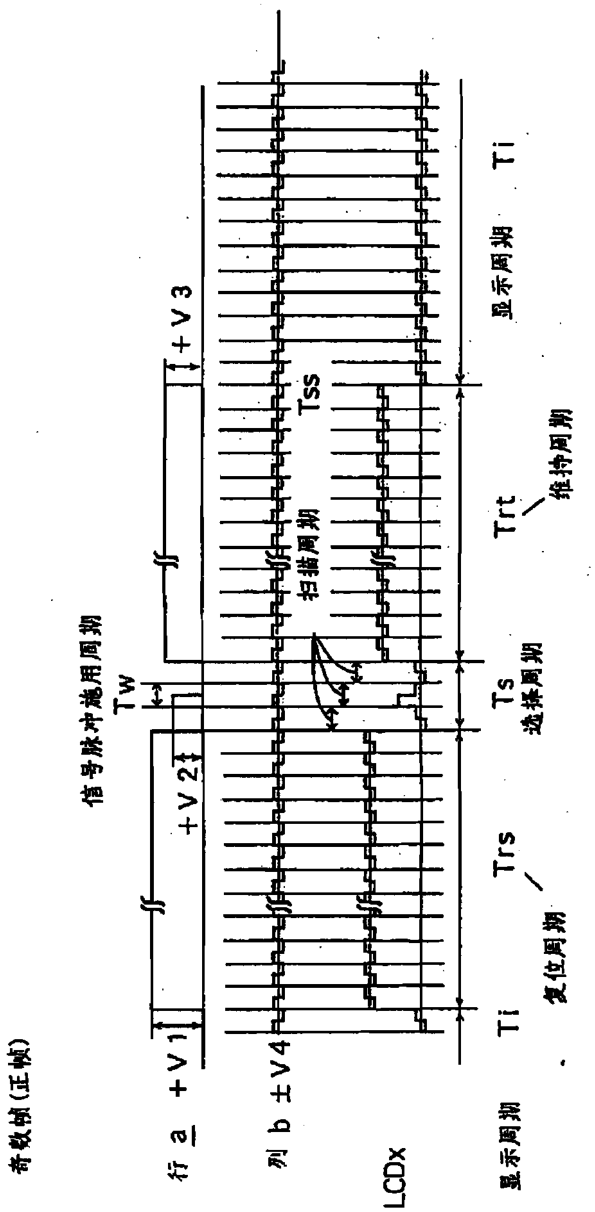

奇数帧(正帧)
行 a +V1
+V2
+V3
列 b ±V4
LCDx
显示周期
Ti
Trs
复位周期
信号脉冲施用周期
Tw
Ts
选择周期
扫描周期
Tss
Trt
维持周期
显示周期
Ti

图 11

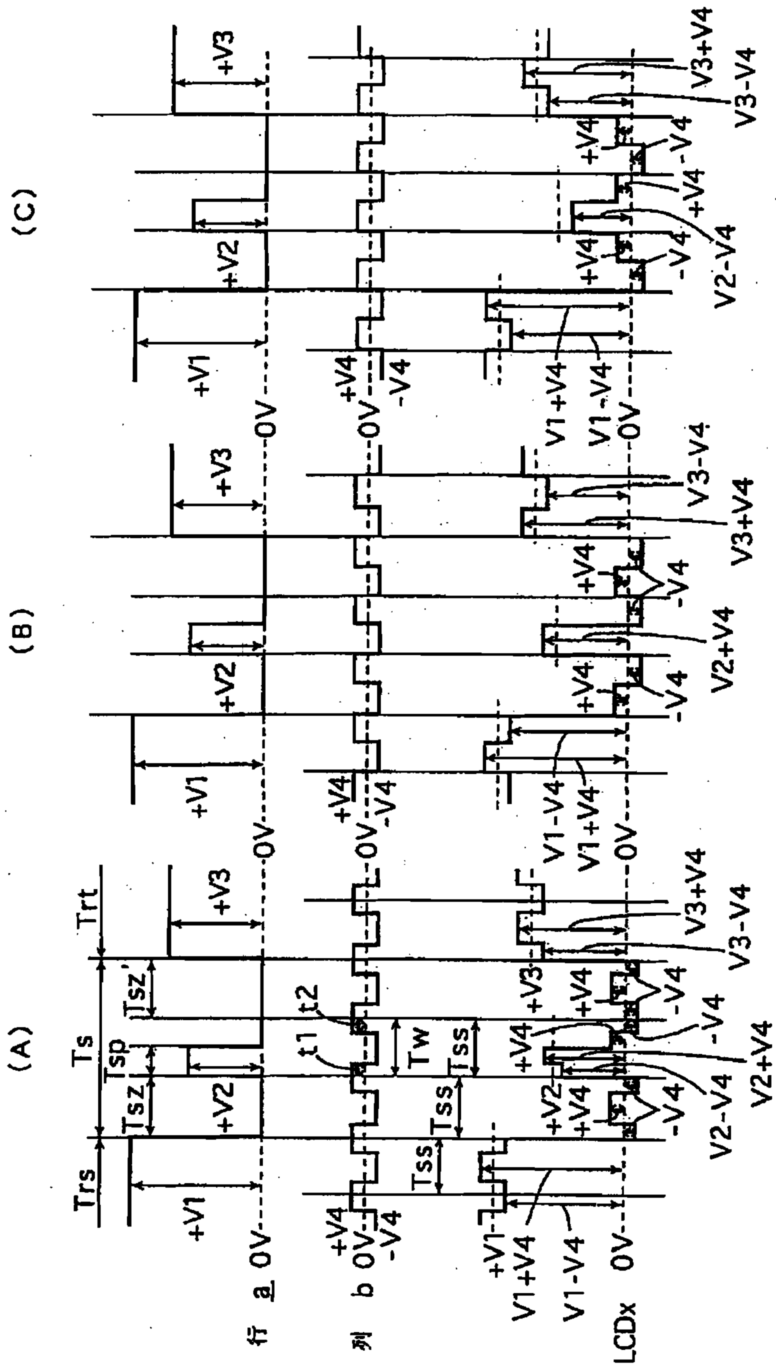

(A)
(B)
(C)
行 a
列 b
LCDx
Trs
Ts
Trt
Tsz
Tsp
Tsz'
Tw
Tss
t1
t2
+V1
+V2
+V3
+V4
-V4
0V
V1+V4
V1-V4
V2+V4
V2-V4
V3+V4
V3-V4

图 12

(A)

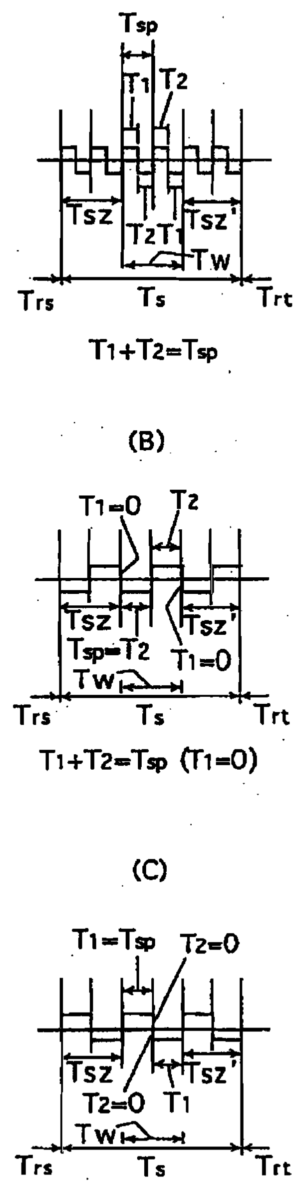

Tsp
T1 T2
Tsz
T2T1
Tsz'
Tw
Trs Ts Trt
T1+T2=Tsp
(B)
T1=0 T2
Tsz
Tsz'
Tsp=T2 T1=0
Tw
Trs Ts Trt
T1+T2=Tsp (T1=0)
(C)
T1=Tsp T2=0
Tsz
Tsz'
T2=0 T1
Tw
Trs Ts Trt
T1+T2=Tsp (T2=0)

图 13